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NATURE STUDY

BY GRADES

A TEXTBOOK FOR HIGHER GRAMMAR GRADES

BY

HORACE H. CUMMINGS, B.S.

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The child cannot get power of judgment excepting as he is continually exercised in forming and testing judgments. He must have an opportunity to select for himself, and to attempt to put his selections into execution, that he may submit them to the final test, that of action. Only thus can he learn to discriminate that which promises success from that which promises failure; only thus can he form the habit of relating his purposes and notions to the conditions that determine their value. Does the school, as a system, afford at present sufficient opportunity for this sort of experimentation? Except so far as the emphasis of the school work is upon intelligent doing, upon active investigation, it does not furnish the conditions necessary for that exercise of judgment which is an integral factor in good character.

JOHN DEWEY.

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ENTERED AT STATIONERS' HALL, LONDON.

CUMMINGS'S NATURE STUDY.

W. P. I

PREFACE

SINCE the majority of children never reach the high school, and therefore must depend for whatever scientific knowledge they acquire upon the work done in the grades, it has been one aim throughout this Nature Study Series to give pupils in a simple way a fair understanding of the fundamental principles of the natural sciences. It is believed that this will form a most useful basis for the interpretation of subsequent experiences, and also will help the pupils to comprehend and use better the knowledge accumulated as they grow older.

This third book of the Nature Study Series is designed to meet the needs of pupils in the sixth, seventh, and eighth grades of elementary schools. While its general plan follows that of the earlier volumes, the subjects treated cover a wider range of observation and experience. In the adaptations of the lessons to meet the needs of the class and to fit the materials at hand to study, the teacher should exercise the same liberty as previously suggested. Many of the lessons may be extended indefinitely by giving added directions, orally or upon the blackboard, for further experiments, observations, or research. An effort is made in the eighth grade work especially to develop the uses and methods of classifying knowledge, — a thought that the teacher may with profit carry further than is provided for in the text.

That teachers and parents, as time passes, will appreciate more and more the need of the growing intellect to be placed in contact with the real objects and laws of the material world, until Nature Study in some form becomes *the first essential* in an elementary education, is the firm conviction of the author.

H. H. CUMMINGS.

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SIXTH GRADE—FALL WORK

Summer is gone, Autumn is here,
This is the harvest for all the year.
Corn in the crib, oats in the bin,
Wheat is all threshed, barley drawn in.
Carrots in cellar, beets by their side,
Full is the hayloft, what fun to hide!
Apples are barreled, nuts laid to dry,
Frost on the garden, winter is nigh.
Father in Heaven, thank Thee for all,
Winter and springtime, summer and fall.
All Thine own gifts to Thee we bring,
Help us to praise Thee, our Heavenly King.

—LYDIA A. COONLEY.

LESSON I

UNITED STATES WEATHER MAPS

TO THE TEACHER.—The nearest Weather Bureau will mail to any school the daily weather maps free of charge. A suitable frame in which to place them may also be obtained there. These maps should be hung where all the pupils can see them. Special attention should be given to the study of weather in this grade and opportunity should be taken throughout the year to let the pupils observe and report in the class upon the various changes and conditions of the weather and tell their causes and effects.

1. Why does our government send free weather maps and reports to the people? Why do the newspapers print them free of charge?

2. How may a foreknowledge of the weather benefit the sailor? the farmer? the orchardist? the carpenter? the flock owner? the merchant? the people generally? Give practical illustrations in each case.

3. What precautions does each take to avoid loss or harm?

4. Do the weather forecasts of the government come true in every instance? When did one fail?

Note.—More than 80 per cent of the forecasts are verified, and this per cent is gradually rising. Why?

5. Study carefully a weather map and learn the meaning of all the symbols and abbreviations on it.

6. What is the meaning of the curved lines? the dotted lines? the small circles? the arrows?

7. How is rain or snow indicated? cloudiness? wind?

8. Explain the meaning of "High" and "Low" areas.

9. Prove from the map in what direction the winds blow in relation to an area of high pressure. Examine several maps and discover the law in this respect.

10. In like manner discover in what way the wind blows in relation to an area of low pressure.

11. To maintain these winds, what must be the vertical movement of the air over a "Low Area?" over a "High Area?"

12. How may a descending air current affect the pressure on the barometer? Why? Is such a current generally cold or warm? Why?

13. How may an ascending air current affect air pressure? Why?

14. What kind of weather does a low barometer indicate? Why?

15. Why is it usually fair in the areas of high pressure?

16. Watch the barometer and learn to forecast the weather by its actions.

17. Study each day's weather map and note the changes in the weather conditions. Trace the movements of storms, cold waves, winds, etc.

LESSON II

STORMS AND STORM SIGNALS

1. How fast does a storm or cold wave travel across the country?

2. How may its time of arrival at any particular place be estimated?

3. What is the difference between a local and a general storm?

4. Under what conditions do local storms generally occur?

5. Study a thunder storm. What time of the year are they most frequent? Why? Why do they generally occur on a sultry day? In what part of the day do they most frequently occur? Why?

6. In what part of the sky is the rainbow most frequently seen? Why? Where is the sun, always, from the rainbow?

7. How long do thunder storms generally last? Compare with the duration of general storms.

8. Which kind has more thunder and lightning? In which case is the rainfall more steady and uniform? Which kind does the more good?

9. Explain the cause of a thunder storm and account for its various features.

10. How does the Weather Bureau station inform the people of approaching changes in the weather?

11. What kind of flag indicates wind? rain? temperature?

12. Tell how these different kinds of flags are used to indicate the different kinds of weather.

13. How are the directions of the wind indicated?

14. Describe the hurricane signal; the cold wave flag.

15. How are changes in temperature indicated by flags?

16. Draw the various flags used by the signal stations in their respective positions to show the various changes in weather conditions.

Note.—In some regions on the coast weather and temperature signals are given by steam whistles, long blasts being used to indicate weather changes and short blasts, temperature changes.

17. Find out the meaning of one long blast; two long blasts; three long blasts.

18. Learn also the meaning of one, two, and three short blasts.

19. Why are blasts more convenient than flags in such places?

LESSON III

VALUE OF SUNSHINE

1. Why do house plants so often bend their leaves toward the light?

2. Which side of a leaf always faces the light?

3. Why is the sunflower so called?

4. Do leaves on trees change their position as the sun moves through the sky?

5. Tell what you know of the effects of sunshine upon plant growth. Give examples.

Experiment.—Repeat the experiment in Lesson 3 Grade 5, page 112, in the darkness and in the sunshine and note in which the activity of the plant is the greater. See that temperature and other conditions are equal.

6. Why does the Weather Bureau always report the amount of sunshine each day and month?

7. What is the effect upon crops of a long, sunny, dry spell? Of a long spell of cloudy, rainy weather?

8. What advantage is it for people to be kept informed as to conditions and prospects of crops?

9. What states are noted for the great amount of sunshine they have? What crops thrive best there?

10. Where do sugar beets contain the most saccharine matter, in the arid or in the humid states? Where are the most of the great beet sugar factories? Why?

11. Does sunshine affect animals? How?

12. On what kind of days do bees gather most honey?

13. What animals love to bask in the sunshine?

14. What effect has sunshine upon our health?

15. Why should sunshine enter every room in our homes?

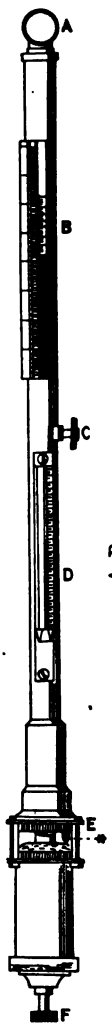
16. What happens to mold and mildew when they are exposed to the rays of the sun? Prove this by trying it.

17. Mention other effects of sunshine.

LESSON IV

VISIT TO A WEATHER BUREAU

TO THE TEACHER.—Take the class to visit the Weather Bureau. The officials in charge are generally glad to conduct pupils through and explain to them the use and construction of the various instruments found there. Arrangements for the visit should be made beforehand.



A BAROMETER

A is a ring by which the barometer may be hung from a nail or hook; *B* is an opening in the cover that surrounds the glass tube, exposing the surface of the mercury beside a scale which measures its height above the surface of that contained in a cistern at the bottom of the instrument. *C* moves a vernier over the scale to secure more accurate readings; *D* is a thermometer attached; *E* marks the surface of the mercury into which the glass tube is inserted, and *F* is a screw which adjusts the surface to the proper level indicated by a pin at *e*.

The following instruments and devices are usually found at the Weather Bureau where they may be seen and studied and afterward discussed in the class until the pupils understand them:

THE THERMOMETER

1. How does the thermometer at the Weather Bureau differ from the one at school?

2. Where is it placed and how is it protected from the sun?

3. How is the maximum temperature recorded? the minimum temperature?

4. How often do the operators record the temperature?

5. How do they get the average temperature of the day? of the month?

6. What is meant by "accumulated temperature?"

7. When unusual temperature threatens, what warnings are sent out from the Weather Bureau? In what ways do these warnings do good?

THE BAROMETER

1. Describe the barometer.

2. In reading it, how do they tell the number of inches? the tenths of inches? the hundredths of inches?

3. Explain a vernier. Make one.

4. How does the air reach and act upon the mercury in a barometer?

5. How would its reading be affected by taking it up in a balloon? Why?

6. How may it be used in measuring the height of mountains?

7. Why does the air grow lighter as we go upward? What effect will this have upon the height of the barometer?

Note.—As we ascend, the mercury will fall in the barometer about one inch for each 1,000 feet.

8. What is meant by reducing the readings of the barometer to sea level? Why is this necessary in making up the weather maps and reports?

9. What is the average height of the barometer at sea level? What is it in your city?

The Rain Gauge

1. Describe the rain gauge at the Weather Bureau. Wherein is it better than the tin can used at school?

2. Where is it placed? Why?

3. How is the rainfall caught and measured?

4. What is the average rainfall in your locality?

5. Would the effect be beneficial or otherwise if the average rainfall in your region were increased? if it were diminished? Why?

6. From what direction does most of the rain there come?

7. Draw a rain gauge and show how its measurements of the rainfall are rendered accurate.

The Wind Gauge

1. How is the velocity of the wind measured?

2. How is it recorded?

3. Describe the wind gauge and explain its actions.

4. Describe the instrument that records the wind's velocity.

5. How fast does the air move in a zephyr? in a breeze? in a gale? in a hurricane?

6. How is the information obtained by the wind gauge of use to man?

7. In what ways is the wind used by man? In what ways is it harmful to his interests?

Other Instruments

1. How would an earthquake shock be detected and its time and intensity recorded?

2. What can you say about the frequency of slight earthquake shocks?

3. Tell of some destructive earthquakes.

4. Can earthquakes be foretold and the people warned of their coming?

5. Did you see any other instruments at the Weather Bureau? If so, describe them and tell what you can of their action and use.

Weather Signals

1. Learn to read the weather signals. Of what use are they?

2. What colors are used in the weather signal flags?

3. Describe the different shapes of the flags.

4. Recall the work done in Lesson 2, and add to it whatever you may be able to learn at the Weather Bureau.

5. Make all these signal flags from paper and drill with them until you understand and can remember all the weather signals.

Weather Maps

1. How are weather maps constructed?
2. How are the various items of information collected to be represented on the maps?
3. For example, before the lines representing the temperatures can be drawn on a map issued from the Weather Bureau, what information must be obtained from other places?
4. Could we have weather maps without telegraphy?
5. How does one observation station aid others?
6. How many weather stations are there in the United States?

LESSON V

A COMPLETE WEATHER RECORD

To the Teacher.—In order for the pupils to have an understanding of the weather and its relations to man, animals, and plants, they must make a long series of observations, record them in a systematic way, and compare the data collected from time to time, drawing such inferences as they can while the work progresses. Like so many other topics in nature study, all points about the weather cannot be crowded into one or two lessons; but they must be distributed throughout the year, and the various features discussed when the conditions are favorable and the data collected sufficient. For the convenience of the teacher, however, and to illustrate the method of treatment, a sufficient number of topics is given here to make several lessons and the teacher should provide other lessons occasionally throughout the year, as weather conditions change and as data collected by the pupils render necessary.

1. What is weather?
2. How many kinds of weather can you name?

3. What is the difference between weather and climate?

4. What are the chief elements that go to make up weather?

5. What is the great active agent that causes the phenomena we call weather?

6. How is heat related to wind? to clouds? to snow? to rain, etc.?

7. What is the source of all the heat that influences the weather?

8. Is this supply of heat always the same? When do we get most? least?

9. What conditions determine the amount of heat we get each day from the sun?

10. How does the length of the day affect it?

11. How does the sun's path through the sky affect it?

12. What observations can we make and record each day that will aid us in finding out how much heat we get from the sun each day or month and the reasons why?

13. Tell all you can about the action of heat in producing clouds. Recall the laws of evaporation. (See Lesson 32, Fourth Grade).

14. What part of the earth's surface is water? How does this influence the formation of clouds?

15. Suppose the proportion of land and water composing the earth's surface were reversed, what would be the effect upon the weather? upon the crops?

Experiment.—Find out by suitable experiments how much water the heat of the sun on a warm day at this latitude will cause to evaporate from a given surface.

16. On what part of the earth's surface is there the greatest evaporation? Why? Where, then, will there be greatest rainfall?

17. As the sun moves north or south of the equator, how will this region of rainfall change? Why?

18. Account for the daily rains near the equator. Why do we not have them here?

19. Why do they have a wet season and a dry season within the tropics instead of our summer and winter?

20. When does the wet season begin in the City of Mexico? Why?

21. When does the wet season begin in the central part of South America? Why?

22. From what direction do the clouds come that bring us rain?

23. What observations can we make each day that will aid us to find out the laws that control our rainfall?

24. Since most of the evaporation takes place at sea, how do the clouds formed there reach us?

25. Tell what you can of winds and their work. Recall the causes of wind. (See Lesson 3, Fifth Grade.)

OBSERVATION WORK.—A weather vane should be placed where all the pupils can tell each day the direction of the wind. They should also estimate its velocity. Compare with the reports from the Weather Bureau.

26. What wind generally precedes a storm in your region? What is the probable source of the rain clouds which furnish the rainfall there?

27. Since we have learned that heat, moisture, and wind are the three great things that make our weather, mention all the observations we can make regularly that will help us to understand each of them and their relations to weather.

28. How may these observations be tabulated in a convenient form for recording and using the data recorded?

Meteorological Record for.....19....

Name.....

Day	Date	Sunrise	Sunset	Length of Shadow	Thermometer	Barometer	Wind	Cloudiness	Rainfall	Frost Dew	Moon Phase	Moon Rises Sets	Morning Star	Evening Star	REMARKS
Mon.															
Tues.															
Wed.															
Thur.															
Friday															
Week's Summary															

29. Show why tabulating the information is better than writing it in the form of an essay.

TO THE TEACHER.—Each feature of the accompanying form suggested for a Meteorological Record should be worked out with the aid of the class so that all pupils will understand its use and necessity. The observations on the sun may be developed first and the other features added from time to time, as they are worked out in the recitations.

LESSON VI

ASTRONOMY

1. Describe the real movement or path of the moon. Recall the study of the moon. (See Lesson 22, Fifth Grade.)

2. Prove that the stars and planets do not move from east to west as they seem to be moving.

3. How long does it take the moon to make one complete revolution?

4. Where is it during the "dark" of the moon? Have you ever seen the dark moon in the day-time?

5. Record the phases of the moon and foretell the times of its changes.

6. Locate Venus. In what part of the sky do we nearly always see this planet?

7. Observe Venus for several months. Why does it appear alternately as morning and evening star?

8. From changes noticed in the position of Venus, can you infer what is its path? Why is it always near the sun? Note carefully its movements with respect to the sun.

9. When Venus is above the sun in the evening, which sets first? Which rises in the morning first? Is Venus then the morning or evening star?

10. When Venus is below the sun in the evening, which sets first? Which rises first? Is Venus in this position morning or evening star?

11. In what positions does Venus rise and set with the sun? Is it then visible? Why not?

12. Does Venus always appear equally bright or of the same size? Infer what must be the path of Venus.

13. Do all the planets give forth light of the same color?

14. What other planets can you name and recognize? How may we tell a planet from a star?

Note.—Almanacs and other publications give the names of the planets to be seen at various times of the year. If possible, look at Venus, Saturn, Jupiter, and the moon through a good telescope.

15. Watch the movements of planets among the stars. Do new ones appear? Do any disappear?

16. When an eclipse of the sun occurs, watch it through smoked glass and see the moon pass slowly between us and the sun, cutting off the latter's light. In what direction will the moon be moving?

Three or four of the larger moons of Jupiter may be seen through good opera glasses. They revolve so rapidly around Jupiter that their changes will be quickly noticed.

LESSON VII.

INFLUENCE OF WEATHER UPON PLANTS

OBSERVATION WORK.—Early in the fall select several trees to observe throughout the year. Choose those having different habits and structure, and located near your home or the school. Draw or paint them each month and write carefully a description of all the changes noticed in each. Thus an illustrated history of the year's growth will be written.

1. Which tree has made the greatest growth thus far this season? Measure twigs on each and find which has the greatest length of new wood.

2. How can we tell this season's growth?

3. Are the twigs still growing? Measure several on each tree, record the length of each, and measure them again a week or two later.

4. What trees grow rapidly? Which grow slowly? Do hard wood trees grow as rapidly as soft wood trees? Why?

5. Find out when the trees cease growing for the season. Why do they cease? In what month does the greatest growth occur? Why?

6. What trees or plants are injured by the frost? Describe the effects of frost upon plants that are frost-bitten.

7. Which begin to shed their leaves first? Find out why the leaves fall. Collect autumn leaves. Do you think the frost gives them their beautiful colors? Use them for painting lessons and for decorating the room.

8. When does the sap cease to flow? When does it begin again?

9. When do boys in the country make willow whistles? Why?

Experiment.—Try to remove the bark from various twigs in the fall. Note how the inner layer hardens into wood. Account for the rings seen in a cross section of a limb or trunk. Examine the bark in a similar way in the spring.

10. Where is the sap obtained for the trees? What causes the roots to cease furnishing the sap?

11. What kind of season is most favorable to the growth of crops?

12. What crops are injured by a very wet season? What

crops are injured when it is too dry? Give examples that you have seen.

13. What is the effect upon prices of a partial failure of crops?

14. What is the greatest change in price that you have known from this cause?

Note.—Business men who buy and sell great crops of corn, wheat, cotton, rice, tobacco, etc., often many months before they are harvested, watch the weather with great interest. How may the weather cause them a great loss?

15. Tell of fruit crops that you have seen injured by unfavorable weather.

16. Mention crops that are "tender" or easily injured by cold.

17. Which are "hardy" or rarely injured by frost?

18. Where is the natural home of the tender fruits and vegetables, north or south of us? Why?

19. What fruits and vegetables thrive in countries north of us? In countries south of us?

20. Tell how various crops are cared for after harvest, e. g., various grains, fruits, and vegetables. Describe a granary; a grain elevator; a potato pit; a fruit cellar.

21. If not properly cared for, how may these crops be injured during the winter weather?

22. Examine carefully the soil in vacant lots or beside the path and see if any seeds are germinating now.

23. What weather conditions favor the germination of seeds? At what season of the year do most seeds germinate?

24. How may the weather affect young plants that germinate in the hot, dry months? in the late autumn? during a warm spell in winter?

25. Why is springtime most favorable for planting crops?

26. What seeds are apt to be injured by winter weather?

27. How are the seeds of most wild plants adapted to withstand the winter weather? What care is taken of the seeds of cultivated plants in winter?

28. Account for the general conditions of plant life during each of the four seasons.

29. Account for the conditions and the varieties of plants in the great zones of the earth.

LESSON VIII

INFLUENCE OF WEATHER UPON ANIMALS

1. At what rate is the average temperature changing? Consult your meteorological record.

2. How are other weather conditions gradually changing?

3. How do these conditions affect plants? Describe the condition and gradual changes in trees and smaller plants. Which have completed their year's work? Which have just begun?

4. What plants furnish food for domestic animals? What roots do animals eat? What stems? What seeds? What fruit? What leaves?

5. What plants furnish food for insects? for birds? for wild animals? Do any fishes eat plant food? Do any reptiles eat it? What plants are now being eaten by animals?

6. How is the gradual change in weather affecting the food supply of animals? Consider the condition of all the various parts of plants that furnish food for animals.

7. How do plants afford shelter for animals? Consider the

shade of trees, the foliage, the leaves, bark, etc., as places of shelter.

8. How does the weather affect the shelter of animals? Which animals are inconvenienced most in this regard by the approach of winter?

9. How does man provide food and shelter for his domestic animals during the cold weather?

10. Besides affecting the food supply and shelter of animals, in what other ways does the change in weather now going on inconvenience them?

11. What animals can best endure the cold weather? Why?

12. What animals disappear first as cold weather approaches? Consult your Natural History Calendar.

13. Consider the relative ability of insects, reptiles, fishes, birds, and beasts to endure winter weather.

14. What insects may be seen active now? Make a list of them. What do they eat? How does the weather affect them? Notice carefully the house fly, honeybee, butterfly, mosquito, and other common insects and learn from observation the effects of cold weather upon them.

15. How are toads, frogs, lizards, snakes, etc., affected by the approaching cold weather? What becomes of them in the late fall? Consider their food, shelter, and ability to endure cold weather.

16. What are the birds doing now? What food do they eat now? Would their summer nests make good winter shelter? What shelter have you seen birds seek during a severe rain, wind, or snow? Observe what they do as winter approaches.

17. Which kind of animals mentioned is, perhaps, least affected by the conditions of the weather? Why? What do

fish eat? What forms their shelter? How are they protected from the extreme cold?

18. How are the larger four-footed animals influenced by the weather? Which remain with us during the winter? Which disappear? What food do they eat? What shelter have they? How does nature protect the winter dwellers from the cold?

19. How does the weather influence the distribution of animals over the surface of the earth? Make a list of the animals found in each zone. Tell how they are adapted for the climate they have chosen to live in.

20. Notice the effect, upon animals, of unusual storms, hot waves, or blizzards, and report to the class what you observe.

21. Are the eggs or larvæ ever killed by the cold winter? Does freezing injure grasshopper eggs, the bees in the hive, the deeply buried toad, or the fish under the ice on which you skate? What animals have you known to be killed or injured by cold weather?

22. Have you ever known animals to be overcome by heat? Will strong sunshine injure any animals?

23. What kind of weather is most favorable for the production of mosquitoes, and house flies?

LESSON IX

ISOTHERMS AND WHAT THEY MEAN

1. What is an isotherm? an isobar?

2. On weather maps why do isotherms generally run across the map irregularly, while isobars are often in curves?

3. Trace across a weather map the isotherm of 60°; of 32°; of zero.

4. Compare these isotherms month by month and note how they move on the map. As winter approaches, how do they move? How will they move as spring comes? Why?

5. Why do not all points equally distant from the equator have the same temperature? If they had, how would the isotherms then run?

6. Follow any isotherm across the map and account for any bends to the north or south that you find in its course. How do high mountains influence the direction of the isotherm?

7. Show how winds, ocean currents, and lakes, or other bodies of water, influence temperature.

8. What plants cannot survive freezing weather? What will the isotherm of 32° tell us about such plants?

9. What plants are killed by zero temperature?

10. What is the most southern point reached by a temperature of 32°? by a temperature of zero?

11. What do these isotherms tell us about plant life in their regions? What do they tell us about animal life there?

Note.—The average temperature of any locality has so great an influence upon its plant life that botanists tell us that a change of a single degree would cause a wonderful change in the plants that grow there.

As a practical illustration of this truth, some grape vines of a tender variety, which thrive well in southern California, were planted by the author in an experiment garden in a much colder climate. For five years in succession they produced grapes which did not ripen; the frosts came too early in the fall. The sixth summer was exceedingly dry and hot. The spring opened nearly two weeks earlier than usual, and the frosts in the fall were delayed nearly as long. This made the growing season almost a month longer than usual and the grapes ripened and were fine. During the four warmest months that summer

the accumulated excess of temperature was only 82°—an average of only about two thirds of a degree a day. If this increase in the temperature were to become permanent, those grapes could be raised with profit where they are now valueless. Many wild plants, too, that cannot now mature their seeds so far north would soon find a place among those now growing there.

LESSON X

HUMIDITY—DEW

1. Describe dew. Where is it found? On what is it found? On what does it not form?

2. When does it usually form? Why does it not form in the daytime as well as at night?

3. Does it form on nights that are clear? cloudy? warm? windy? cool? calm?

4. Where does the dew come from?

5. Recall the principles of condensation (Lesson 35, Fourth Grade) and explain how dew is formed.

Experiment.—Breathe against a cold glass; then against a warm one. Account for the different results.

6. Why does dew form on some objects and not on others?

7. How does heat influence evaporation? Which contains more moisture, hot or cold air? Prove this.

8. How does lowering the temperature affect its power to hold moisture? Think of an illustration to prove this.

Note.—When the air is cooled until the moisture in it is on the point of condensing into water, it is said to have reached the dew point.

9. Does the amount of moisture in the air affect the dew point? Explain how.

10. What conditions cause a heavy dew? Under what conditions is there little or no dew formed?

11. What is the effect of a strong wind upon the formation of dew? of an increase of temperature?

12. Where are the humid regions in the United States? the arid regions? Compare the rainfall in these regions. Account for the difference in rainfall. Is there a similar difference in the amount of dew formed in these regions?

13. Upon what two things does the amount of dew formed depend? Is this true also in producing rain?

14. Does it always rain or snow when the barometer falls?

15. If a dry current of air ascending causes the barometer to fall, will it cause the same kind of weather as it would if it were moist?

16. When the barometer tells us that the air is lighter, or rising, what must we also know about the rising air before we can judge the amount of rain that may fall? If the air is very damp, what may we expect? If it is very dry, what may be the result?

LESSON XI

THE HYGROMETER

Experiment.—Fasten two similar thermometers side by side to a small, upright board, at the bottom of which is a shelf large enough to support a small, wide-mouthed bottle as shown in the illustration. Wrap one of the bulbs with one end of a piece of soft muslin and let the other end reach downward into the bottle, which should be filled with clean water. The water will soak upward and keep the bulb wet.

1. Fan this hygrometer or whirl it through the air, then

read both thermometers. Explain the difference in the readings.

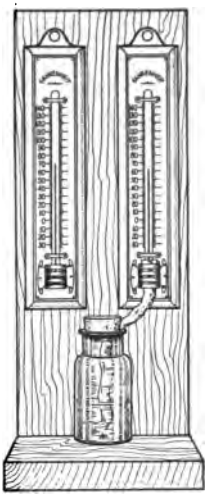
2. Why should we fan or whirl the hygrometer?

3. What effect has rapid evaporation upon temperature? (See Lesson 34, Fourth Grade). Give illustrations.

4. Does dry or moist air cause the more rapid evaporation from the wet bulb?

5. Under which conditions, then, will the difference between the readings of the two thermometers be the greater?

6. Explain how the hygrometer indicates the amount of moisture in the air.



A HYGROMETER

Note.—By a long series of experiments a table has been prepared from which the humidity of the air can be told from readings of the hygrometer.

7. Explain how the hygrometer can aid the barometer in telling when there will be rainfall, and whether it will be heavy or light.

8. If the barometer falls a great deal and the difference between the wet and dry thermometers is slight, what kind of weather may be expected? If there is a great difference between the thermometers, what kind of weather may we have? Explain.

LESSON XII

MIGRATORY ANIMALS

TO THE TEACHER.—Each pupil may be assigned a different migratory animal to study and asked to report subsequently to the class all that

he can find out about it from personal observation, from inquiry, and from books. During the fall months the Natural History Calendar should be kept with care, and the observations recorded by the students should be discussed occasionally in the class.

1. What animals are to be seen now? Make a list of them.

2. Have any disappeared that were with us during the summer?

3. Why cannot they all remain here during the winter?

4. Mention various ways in which animals pass the winter.

5. What animals do you know that migrate, or go elsewhere to pass the winter? Make a list of all that you can remember.

6. Why are most of them birds? Why do not other animals migrate as commonly as birds do?

7. Compare birds with other animals in the following respects: (a) speed; (b) ability to make long journeys; (c) method of travel; (d) powers of endurance; (e) intelligence; (f) likes and dislikes; (g) food supply; (h) shelters; (i) ability to withstand cold weather.

8. What are the birds doing now? Are any of them nesting? Do they go in pairs? Do they sing now? Have any of them changed their garb?

9. What would be the chief dangers to the birds if they all remained with us during the winter?

10. Would they serve man as well in winter as they do in summer?

11. What birds do remain with us all winter? Make a list of them. What do they eat? What is their shelter? How are they prepared to survive the winter?

12. Where do birds go to pass the winter? How long are the journeys they make?

Note.—Many of the birds of the Eastern states pass the winter in the Southern states, though the bobolink goes as far south as Brazil. The "fly-lines" of some swallows are 10,000 miles long. The golden plover breeds in Arctic America and winters in Patagonia.

13. What dangers do birds meet in their long journeys? Have you seen any that were injured while migrating?

14. Do they go singly or in flocks? Do they travel by day or by night? Do they ever utter cries as they go?

Note.—Great numbers of birds are killed by heavy rains and hail storms, while sleet and snowstorms are even more severe on them. More than fifteen hundred have been picked up at the foot of Bartholdi Statue in New York harbor after a dark night in the migrating season. They were no doubt attracted by the bright light and dashed against the glass in their swift flight. Many die from fatigue, while others are blown out to sea and fall exhausted in the water to perish.

15. What advantages do the birds find in their winter home? Why do they return to us in the spring? Do they seem glad to get back?

16. What dangers have the birds here in summer? Why are they so wild? How may we lessen these dangers?

17. A cat has been known to kill fifty birds in a single day. How many have you seen killed or injured by thoughtless persons throwing stones or shooting at them?

18. What assistance may we give to useful birds in view of the many perils that destroy them? Why do such birds not become extinct?

19. Do any birds come to us to spend the winter? Name some that do.

20. Tell what you can of the snow bird—his size, color, habits, food supply, shelter, his power to endure cold, and his service to man.

21. Give an account of any other visitants with which you are familiar.

22. Do any quadrupeds migrate? To what extent? Why?

23. Why is it not so necessary for them to migrate?

24. Do you know of any insects that migrate?

Note.—Some butterflies, crickets, and the common grasshopper will, at times, migrate for a considerable distance.

25. Do you know of any reptiles or fishes that migrate?

26. Is man benefited in any way by the migratory habits of animals? How does the hunter take advantage of it? When is the season's catch of salmon made at the great packing houses on the Columbia River?

27. Do cattlemen and sheepmen keep their herds on the same range both summer and winter?

TO A WATERFOWL

Whither, midst falling dew,
While glow the heavens with the last steps of day,
Far, through their rosy depths, dost thou pursue
Thy solitary way?

Vainly the fowler's eye
Might mark thy distant flight to do thee wrong,
As, darkly seen against the crimson sky,
Thy figure floats along.

Seek'st thou the plashy brink,
Of weedy lake, or marge of river wide,
Or where the rocking billows rise and sink
On the chafed ocean-side?

There is a Power whose care
Teaches thy way along that pathless coast—
The desert and illimitable air—
Lone wandering, but not lost.

All day thy wings have fanned,
At that far height, the cold, thin atmosphere,
Yet stoop not, weary, to the welcome land,
Though the dark night is near.

And soon that toil shall end;
Soon shalt thou find a summer home, and rest,
And scream among thy fellows; reeds shall bend,
Soon, o'er thy sheltered nest.

Thou'rt gone, the abyss of heaven
Hath swallowed up thy form; yet, on my heart
Deeply hath sunk the lesson thou hast given,
And shall not soon depart.

He who, from zone to zone,
Guides through the boundless sky thy certain flight,
In the long way that I must tread alone,
Will lead my steps aright.

—WILLIAM CULLEN BRYANT

LESSON XIII

HIBERNATING ANIMALS

1. What animals sleep or lie dormant most of the winter? Make a list of all you know.

2. Describe the appearance and condition of any you may have seen. What shelters do they seek for winter?

3. Examine nooks and corners, cracks and crevices, and other sheltering retreats where small animals might hide to spend the winter. Report your findings.

4. Which burrow in the ground? Tell what you know of the mole, gopher, prairie dog, or other burrowing animal. How deep do they make their burrows? Suggest a reason.

5. Which bury themselves in the mud or soft earth? If

possible, find out where the toad, frog, tortoise, etc., hide during the winter.

6. What animals have you seen dug or plowed up in the spring? How did they become buried?

7. Which animals spend the winter in hollow trees? Which are sometimes found in caves and dens?

8. What can you say of their food supply during the winter? Would it be enough for them if they did not sleep so much of the time? Why are they lean and poor generally in the spring?

9. Why do not these animals migrate? Consider their movements, structure, coverings, intelligence, food, etc.

10. Which are warm blooded and which have cold blood? How do they contrive to keep themselves warm enough?

11. Will any of them live after being frozen?

12. Which are protected by a warm covering?

13. Tell all you know about any common hibernating animal. Select one or more for special study and find out all you can about them.

LESSON XIV

METAMORPHIC ANIMALS

1. What animals change little except in size, from birth to maturity?

2. Mention animals that make very important changes in form and habits in their growth to maturity.

3. Mention animals that produce living young. How do their young compare with the adults?

4. Mention animals that are hatched from eggs. Compare the young and the old of such animals.

5. What class of animals pass from the egg through several different forms or stages before reaching the perfect, or adult stage?

6. Describe the life history of the mosquito; the house fly; the honeybee.

7. In what form or stage of development do most common insects pass the winter? Why is this a wise provision?

8. What insects, abundant in summer, have already disappeared?

9. Note in your Natural History Calendar the insects that are now active and find the time of their disappearance.

10. What becomes of most insects during the winter? Why do not they migrate as the birds do?

11. What is the food of most insects? How is the supply affected by winter conditions?

12. What insects pass the winter in the egg stage? Examine twigs and bark where eggs might be found and collect as many kinds as you can.

13. What insects pass the winter in the pupæ stage? Hunt for cocoons and pupæ of various insects and keep them in a larvæ box until spring.

14. Do any insects pass the winter in the adult form? Is it an advantage to kill the straggling fly, wasp, or mosquito seen during cold weather? What work will they do for their race by living until spring?

15. Study several common insects and learn from observation the several stages through which they pass and their habits in each stage.

16. In what stage are various harmful insects most in-

jurious to man? Why? Give examples. In what stage do they do least harm?

17. How many generations can be produced in a single summer? Consider any common insect that you know.

18. What are the most common enemies to insects?

19. Make a collection of insect nests and cocoons and discover the changes they undergo in developing.

20. In what ways do insects injure mankind? How does man protect himself against insects?

21. In what way do insects aid man? Which are cultivated by him? Why?

22. How do insects aid plants?

23. Are insects the only animals that pass through a metamorphosis? Describe the life history of a common toad or frog.

24 Describe the structure and habits of any of the common insects, and learn how they are adapted in many ways for the life they lead.

LESSON XV

WINTER DWELLERS

1. Mention animals that may be seen active all winter. Make a list of them.

2. Which of them eat plant food? Which eat flesh? Which live on insects?

3. How do winter conditions affect the food supply of each kind?

4. What shelter, if any, does each kind secure when the weather is cold and stormy?

A HUNTER'S CAMP

5. How is their covering a protection to them from the cold and storms?

6. Are their coverings of the same weight and warmth in summer as in winter? Tell of any changes you have noticed in animal coverings in this respect.

7. When do these animals "shed" or "molt?" Why?

8. How does man make use of the winter coverings nature gives to animals?

9. Which animals has man tamed chiefly for their coverings? How does he use them?

10. What wild animals are trapped and killed for the same purpose? Which of these have you seen alive?

11. Describe any of the fur-bearing animals you know. Where do most of them live? Why?

12. Which of the winter dwellers are useful to man? Tell how each one mentioned is made to serve a useful purpose.

Note.—Make a special study of one or more whose habits may be observed. Report to the class things learned from time to time.

13. Which winter dwellers are detrimental to man? How may these be restrained or destroyed?

Note.—In most states there are game laws that protect useful animals; and in the more sparsely settled ones, there are laws to provide a bounty for the destruction of injurious animals.

14. Find out some of the animals protected by law in your state, and give a reason.

15. If there is a bounty offered for killing any, find out for which ones, and why they should be destroyed.

LESSON XVI

THE DOG

1. Name and describe as many breeds of dogs as you can.

2. What does the dog eat? How often should he be fed?

3. Tell how he drinks. Does any other animal drink the same way?

4. Examine the dog's teeth; for what kinds of food are they adapted?

5. Compare his tongue with that of the cat or other carnivorous animal. Why is it not rough? Why does a dog often bury a bone given him?

Note.—The dog in a wild state lived largely on carrion.

6. Compare the dog with the cayote, wolf, fox, etc. Consider the head, teeth, feet, covering, foods, habits, etc., and how each animal is adapted to live in his own way.

7. What can you say of the dog's sense of sight? of his sense of hearing?

8. Why does the dog need the remarkably keen sense of smell that nature has given him? Give examples of the use of this sense.

9. What does the dog express by barking? by growling?

From the painting by Landseer

THE SHEPHERD'S BIBLE

by whining? by howling? What movements or gestures indicate joy? fear? shame? anticipation? Describe other means he has of expressing himself.

10. Tell what you can of the dog's disposition. Illustrate by anecdotes or observations the following characteristics, his intelligence, strength, skill, courage, love of master, love of children, patience, perseverance, and ability to learn.

11. Tell of the dog's usefulness in the hunt; with flocks and herds; as a watch dog; in tracking criminals; in doing work, especially as the Eskimo dog works; in doing errands; in playing games and tricks; and in any other ways you can think of.

To THE TEACHER.—This work, done orally or in writing, is a most valuable exercise in language, as it gives the best opportunity for expression under the most natural and therefore the most valuable motive—a desire to tell others what they do not know.

12. What care should a dog receive? How may the fleas on a dog be destroyed? What causes a dog to go mad? What danger is there in the bite of a mad dog?

13. Describe methods of training dogs.

SIXTH GRADE—WINTER WORK

LESSON XVII

ANIMAL COVERINGS—HAIR

1. Mention all the different kinds of animal coverings you have seen. Make a list of them. Collect samples for the school cabinet.

2. What animals are covered with hair? feathers? bristles? fur? wool? scales? shells? skin only?

3. Why is there so great a variety of coverings?

Experiment 1.—Burn samples of hair, wool, scales, etc., and note the odor of each. Do they smell alike?

Experiment 2.—Examine under a microscope samples of hair. Describe the structure of each as you see it.

4. Mention all the animals you can think of that have hair for a covering.

5. How do they compare in size with fur-bearing animals?

6. In what ways is hair the best kind of covering for the animals having it? Imagine wool or fur or feathers or scales being substituted for hair on any of these animals, what trouble or disadvantage would result to them?

7. From what dangers does this covering protect its owners? Consider climate, enemies, environment, possible accidents, etc.

8. Is the color an advantage? Illustrate with examples. Does the color change with the seasons in any case? Why?

9. When and why do animals shed their hair? Give examples.

10. When does the coat become thicker and warmer? Why?

11. Why do owners of fine horses "clip" off the heavy coat of hair in the winter? Is it a good thing for the horse?

12. What animals have very long hair? Which have coarse hair? Which have fine hair? Show in each case an adaptation to the needs of the animal.

13. What uses does man make of the hair of animals?

14. When the hair of an animal is very coarse and stiff, what do we call it?

15. What animals have bristles? Why are bristles a suitable covering for them?

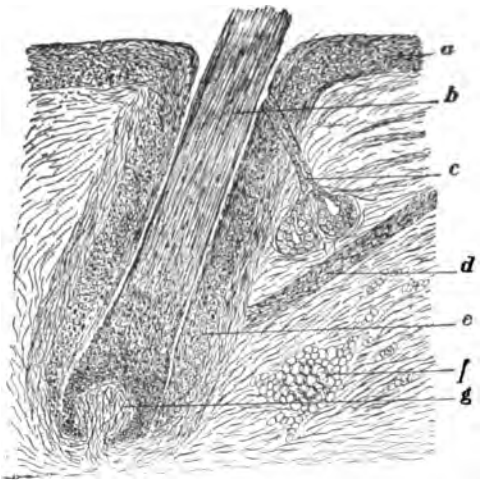
16. What uses does man make of bristles? How are brushes made?

17. What animals are covered with spines? Describe spines and tell what use they serve their owners.

LESSON XVIII

THE HUMAN HAIR

Experiment 1.—Place a human hair between the thumb and forefinger and rub them together in a movement lengthwise with the hair. Which way will the hair move? Turn the hair end for end and repeat the experiment.



A HUMAN HAIR MAGNIFIED

a Outer layer of skin; *b* hair shaft; *c* gland that secretes oil to keep the hair soft; *d* muscle that makes the hair erect; *e* outer skin of the hair root; *f* fat cells in the skin; *g* small projection from which the hair grows.

1. Account for the movement of the hair. If it were smooth like a wire, would it move in that way?

Experiment 2.—Place a human hair on the slide of a microscope; pour on it a drop or two of alcohol and cover it with a thin glass. This causes the air within the hair, which prevents our seeing its structure, to escape and the hair may now be examined to advantage through the microscope.

2. Describe the structure of a human hair.

Note.—The outside of a hair is hard and compact and is formed of overlapping layers like shingles of a house. The interior is hollow and contains the liquids which nourish it and give it color.

Experiment 3.—Burn samples of hair, finger nails, and, if possible, a small bit of cuticle or "dead skin" cut from the callous place on the hand or heel.

3. How do their odors compare? Chemists tell us they are all made from the same substances.

4. Describe the hair of the different races of man. What is the most common color in the human hair?

5. If pulled out, will a hair grow again?

6. Is a hair sensitive? Are the cat's "feelers" the same as hairs?

7. What makes the hair stand on end when we are frightened?

8. What care should be taken of the hair? Consider the effects of combing, brushing, oiling, dyeing, and washing the hair.

9. How is our hair sometimes injured? Consider the effects of curling it with hot irons; of using poisonous hair dyes and hair restorers.

10. Why are more men than women bald-headed?

Note.—Human hair is soft and glossy in health, but often dry and rough during disease. Daily brushing and occasional washing in soft water will keep the hair in good condition.

11. Will so called "hair restorers" cure baldness?

12. How is man's beard—especially his mustache—often a needed protection to him? Do women have the same need of this protection?

13. What is the effect upon the hair or beard of shaving it?

14. Examine under a microscope straight and curly hair, and infer a reason for the curling of the latter.

LESSON XIX

ANIMAL COVERINGS—WOOL

1. Mention all the animals you can that bear wool.

2. Show how it is adapted to their needs better than other coverings would be.

3. Describe the shearing of sheep. When is it usually done? Why?

4. If the sheep were not sheared, what would happen to their coats?

5. Does the heavy coat of wool protect the owner from other dangers than cold? What are the chief enemies of sheep?

6. Tell what you know of the nature, habits, and care of a sheep and its methods of defense and escape from its enemies. (Recall Lessons 28 and 29, Fifth Grade).

7. From the wool dealer get a sample of wool as it comes from the sheep—an entire fleece if possible—and examine it carefully. Use a microscope in examining the fibers.

8. What does an average fleece weigh? What is it worth? What uses does man make of wool? What peculiar structure adapts it for these uses?

9. On what part of the sheep does the finest wool grow? the longest? What parts of the sheep have little or no wool on them? Account for this distribution of a fleece.

Sorting the wool is the first process in manufacturing it.

10. Which side of the fleece is dirty? Why? What portion of the weight of the fleece is lost in washing? Wash some of the sample and find out.

11. How may wool be washed on a large scale? Tell how clothes are washed at the laundry.

12. Before wool can be twisted or spun into yarn, the fibers must be made parallel. How would you suggest doing this?

13. Visit a factory where wool is being manufactured, and study each step through which it passes.

Experiment.—Card some of the wool that has been washed and dried, using a pair of hand cards such as were used a century ago. Twist it into yarn by hand and weave it into a small mat or blanket.

14. Describe an old-fashioned spinning wheel if you have ever seen one. (See cut, page 152, Book I).

15. Explain how a revolving spindle twists a thread.

16. Explain how a loom can make threads cross each other in such a way as to form cloth.

17. After the cloth comes from the loom, what is done with it?

Note.—The principal steps in turning wool into cloth fit for market are as follows: The wool is first sorted, washed, and dried. It is then run through a picker which breaks up the matted wool into a light, fleecy mass. It is next oiled and put into a set of cards to make the fibers parallel, when it is spun and woven into cloth. The lighter kinds, as flannels, etc., are then washed, dyed if necessary, dried, pressed, and rolled into bolts. Heavier kinds for men's wear are "fulled," or put through a machine that mats together the fibers into a more compact fabric. It is then "knapped," or scratched with fine wires, to raise all loose fibers, which, after drying, are cut off very close by a shearing machine. It is then pressed and wound into bolts.

LESSON XX

ANIMAL COVERINGS—FUR

To THE TEACHER.—Take the class to a furrier's and let the pupils see how the furs are cleaned, tanned, colored, and manufactured into useful articles. Get samples of different kinds of fur properly labeled; mount them on a chart, and have the pupils learn to recognize them at sight.

If possible, let the class also visit a taxidermist's, which is often connected with a fur store, and see how various animals are stuffed and mounted in natural positions.

1. What is the chief difference between fur and the other animal coverings studied?

2. Compare the quality of various furs seen at the fur store.

3. Which furs are most expensive? Why? Which are

cheaper? Why? What two things influence most the price of furs?

4. Study closely the structure of fur. Compare the coverings of the dog and cat and describe their differences.

5. Are the individual hairs in fur straight or kinky? Why?

6. Are they all of the same length in the same sample?

7. Infer a use for the "overhairs." Why do furriers often pluck out the overhairs?

Note.—Since air is one of the best non-conductors of heat, the warmth of the fur depends largely upon the amount of air entangled within the fibers of the fur. If fur becomes wet or matted close to the body, it loses much of its power to retain the heat of the body. How do the longer, stiffer overhairs aid in keeping the fur open and fluffy?

8. Name as many fur-bearing animals as you know. Where do most of them live? Why?

9. Are fur-bearing animals generally very large? Why?

10. Will fur protect its owner from other dangers than cold?

11. Is the color of the fur a protection in any case? Give examples. Is the color of fur-bearing animals always the same? Which change color? Why?

12. What can you say of the great warmth of fur and its efficiency in keeping animals warm in the severe weather of winter? Do you think they feel the cold as acutely as we do?

13. Describe methods of obtaining furs from wild animals.

14. In what ways are their furs used by man? Describe articles made of fur.

15. What do you know of the manufacture of felt?

LESSON XXI

ANIMAL COVERINGS—FEATHERS

1. Is the plumage of birds the same in summer as in winter? Tell when and how it changes. Why does it change?

2. Describe the covering of a very young bird.

3. Are all parts of a bird's body covered with feathers? What design is there in the distribution of plumage?

4. Why are not all the feathers on a bird of the same size and shape? Compare feathers from different parts of the body and account for the difference in their size, shape, and position.

5. Why do the feathers overlap? In what direction do they point? Why?

6. Examine carefully the structure of a feather. Explain the fitness of each part for its use. Consider: (a) the central shaft; (b) the vane growing out of each side of it; (c) the hollow quill at the other end; (d) the barbs which form the vane; and (e) the interlocking barbules which hold the vane in proper form.

7. Why do birds "preen" their feathers?

Experiment.—Rub a feather from the vane toward the quill so as to separate the barbs, and ruffle the feather. Now rub it carefully the other way and note how the barbules interlock, causing the feather to become smooth and perfect again.

8. Why are the wing and tail feathers of birds large and strong? Are the barbs on opposite sides of the shaft the same in size, length, direction, etc., in both wing and tail feathers? Account for any difference.

9. Study from a live or stuffed specimen, the feathers of

any common bird and account for their size and arrangement. A common sparrow will answer.

10. Compare a *down* feather with a quill feather. What is the difference in their structure and use?

11. What birds have most down feathers? What birds have fewest? Why?

12. Tell what you know of the industry and trade in the down from the eider duck.

13. What birds are noted for their beautiful plumage? Where are the most beautiful birds found in the greatest numbers?

14. Why is the male among birds usually more beautiful than his mate?

15. What uses does man make of feathers?

16. Why may one kind of feather pillow cost twice as much as another of equal weight?

17. Tell what you know of the raising and marketing of geese feathers.

18. Describe ostrich feathers. What determines their commercial value?

19. How are ostrich feathers obtained? Give an account of hunting the wild ostrich. Describe an ostrich farm.

20. What birds have waterproof feathers? How are they rendered waterproof? Why are such feathers needed by their possessors?

LESSON XXII

ANIMAL COVERINGS—SCALES AND SHELLS

1. Make a list of all the animals you know that are covered with scales. Do most of them have warm or cold blood?

2. Do scales form a warm covering? Do the animals having them need a warm covering?

3. Of what use to the snake are its scales? Consider its habits and mode of travel, and the dangers it meets.

4. How are the snake's scales arranged? Where are the largest ones located? Why?

5. If a live snake can be studied, see if its scales are of any assistance in its movements.

6. What fishes, that you have seen, are covered with scales? Describe the shape or draw the scales of different fishes.

7. Tell how and why the scales overlap.

8. What makes a fish so slippery? What advantage is it to a fish to be slippery?

9. When scales are very large and thick and arranged close together, as those of the alligator, what may we call them?

10. What is the use of such scales to their owner?

11. Does man make any use of the scales of animals?

12. If the scales, instead of overlapping, join and form a more or less solid covering, what may we call such a covering?

13. Describe the covering of a turtle; of an armadillo.

14. Which affords surer protection, scales or shell? Which allows greater freedom of motion?

15. Mention animals that are protected by a shell. If possible, study samples and see how they are adapted to the needs of the animal within. Study a crab, crawfish, or lobster.

16. Describe seashells you have seen. Why are they so much heavier than the shells of land animals in proportion to the size of their owners?

17. What special dangers do sea animals have that require strong shells for protection?

18. Are they as heavy to move in water as they are on land? Why?

19. How are seashells formed? How do they increase in size when the inmate needs more room?

A Land Crab

20. Name seashells that are single. Name others that are made in halves that fit together.

Experiment.—Burn in an alcohol lamp a small piece of oyster shell. Does it give the same odor as other animal coverings? Will fire consume it? Moisten a piece of burnt shell and describe the results.

21. What uses are made by man of the shells of sea animals?

LESSON XXIII

ANIMAL COVERINGS—THE SKIN

1. What animals are covered simply with skin?

2. Why do such animals need no other protection for their bodies?

3. Which of these have their skin greatly thickened and hardened? Why?

4. Where is the home of the largest and most numerous naked animals? What kind of a climate do such animals need?

5. Describe the skin of the common toad and frog. Account for the color and markings of each. Does the skin of either ever change?

6. Which can live on dry land longer, the toad or the frog? Why?

7. Which has the dryer skin? Describe the natural home of each.

8. What other service does the frog's skin perform besides being the covering of the body?

Experiment.—Place an earthworm on a dry surface in the sunshine for a few moments. Do its movements indicate pain? Put it in water or on a moist surface and note the change in its actions.

9. What other animals have a thin, moist skin and live in damp or wet places? Why do they die if kept where it is dry?

10. Examine the skins of worms, grubs, reptiles, fishes, etc., whose bodies have no other covering than the skin, and notice how each is adapted in this respect to its needs and environments.

11. Mention the many ways in which the human skin is adapted to the needs of man. Consider its perfect fit, its flexibility, its sensitiveness, and many functions it performs. (Recall Lesson 28, Third Grade).

12. What effect has manual labor on the skin of the hand? Why is this a wise provision? Mention other animals

whose skin becomes very thick and hard in places where it receives great wear or friction. Account for the thickness of the skin on the soles of the feet. How does going barefooted affect the thickness of the skin on the feet?

13. Is the thickened part sensitive? Test it.

14 Describe the feet of the camel and account for their structure.

15. Does this power of the skin to get hard and thick under pressure and friction ever cause us pain or inconvenience?

Describe a corn. What causes a corn? What is its natural remedy?

Note.—The outside layer of the skin is called the *cuticle* and is not provided with nerves. It protects the underlying, true skin, and is made up of scales from the underlying skin.

16. What further protection does man require than that afforded by the skin? How has nature compensated man in thus giving him an inadequate covering?

LESSON XXIV

LATITUDE AND LONGITUDE

1. What is the shape of the earth? Prove it.

2. How does the difference in the time of sunrise or noon at different places prove the shape of the earth?

3. If the earth's surface were flat like a table, how would this difference in time be changed?

4. If the earth were a cube, how would this change the time of sunrise on its different surfaces?

5. Explain how the sun is rising somewhere all the time.

6. Why do American newspapers often publish events that happen in Europe several hours, by our clocks, before the stated time of their happening there?

7. All these things prove that the earth's surface curves in what direction?

8. How can you prove that it curves in the other direction and is a sphere?

9. How does the North Star appear to a person at the equator? To one at the North Pole? To one half way between the equator and the North Pole? Explain this apparent difference in position. Can you illustrate it with objects on the earth?

10. Can we see the curvature of the earth under any circumstances? Where?

11. To locate points on the earth's surface, what is it necessary to have?

12. What natural line forms a basis from which distances north and south of it may be counted? Why do all people use it?

13. Is there any natural line from which distance east and west may be counted?

14. Why do we use the meridian running through Washington; the French, the one through Paris; and the English, the one through Greenwich, near London?

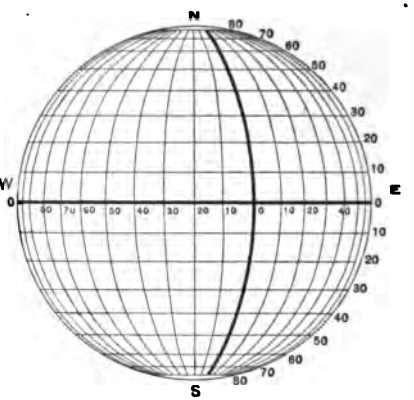
15. Explain the use of the intersecting lines on maps and globes. Which are parallel? Which are not? Why?

16. Give, in degrees, the distance from the equator of London, Berlin, Rome, Sidney, New Orleans, Quito, Cape Horn.

This distance north or south of the equator is called *latitude.*

17. Give the distance east or west of Greenwich of each of the same places.

This distance is called *longitude.*



Note.—On maps and globes longitude is measured by meridians, or lines running around the earth through the poles, and latitude is measured by circles running around the earth parallel to the equator.

18. Which of these circles are of the same size? Which differ in size?

19. Since all circles contain 360°, is a degree always the same number of miles long? Explain.

20. How can a sailor in mid-ocean tell from the North Star how far north of the equator he is?

21. If he has the correct time at Washington, how can he tell by the rising sun about how far east or west of that city he is?

22. How does knowing these two facts tell him where he is?

23. If the sun in its apparent daily course passes around the earth 360° in 24 hours, how many degrees will it pass over in one hour?

24. What, then, will be the difference in time between two places that are 15° of longitude apart? 30°?

LESSON XXV

BUOYANCY OF WATER

Experiment 1.—Suspend from the finger by means of a string, a stone about the size of a man's fist. Lower it into a bucket of water, and withdraw it again.

1. What difference do you notice in the weight of the stone as it enters the water? as it is lifted out of the water?

2. Have you lifted stones or other heavy things under water? How did their weight in water compare with that in air?

3. In dipping up a bucket of water from a stream or spring, why does the weight of the bucket increase as it leaves the surface of the water?

4. Do you think the large shells carried around by many sea animals are as great a burden to them as they would be on land? Why?

5. Why is it difficult to keep one's feet firmly on the bottom when standing in water up to the chin? Mention other examples illustrating this principle.

Experiment 2.—Put an egg into a glass of fresh water; then into a glass of strong brine.

6. Account for the difference in its behavior.

7. Why does a person's body float cork-like on the water of the Great Salt Lake?

8. What danger would be met by a heavily laden boat sailing on the Dead Sea were it to enter the fresh waters of the Jordan River? Why?

Experiment 3.—With a funnel or glass tube carefully add strong brine to the bottom of a glass half full of fresh water. Now put an egg into the water and account for its action.

Experiment 4.—If a vessel of mercury can be secured, try to sink bits of iron, stone, wood, etc., in it. Compare the results with those obtained when water is used instead of mercury.

9. Why does wood float on water?

10. Why does iron float on mercury?

11. Why will an iron pot float on water? If broken into fragments, will the pieces float? Explain why.

12. What causes great battle ships to float when they are covered with thick steel armor and loaded with heavy guns and machinery?

13. Why will they sink when a large hole is shot into them?

14. Upon what does the buoyant force of water depend?

LESSON XXVI

SPECIFIC GRAVITY

Experiment 1.—Punch small holes in the bottom and sides of any tall tin can. Sink it nearly to the top into a bucket of water and notice with what force the small jets of water enter it from each of the holes.

1. In what directions does the water in the bucket press upon the can?

2. Does the can tend to move to either side? Why?

3. Does it tend to move upward? Why? What force keeps the can down in the water?

4. Where does the pressure of the water seem to be greater, near the bottom or the top of the can? Why?

5. As the water gradually fills the can, how is the pressure affected?

Experiment 2.—Hang a small stone to a spring balance or other means of weighing, and note carefully its weight in air. Lower it into a cup brimful of water and sitting in a saucer to catch the overflow. Note the weight of the stone in water and find out how much it has lost in weight. Weigh the water that flowed over into the saucer.

6. How does the weight of the overflow compare with the stone's loss of weight in water?

7. Why does the loss in weight equal the weight of the water displaced? Is this always true?

Experiment 3.—Immerse a cube in water, and study the pressure of the water on each of its sides.

8. How does the pressure on the front face compare with that on the rear in direction and force? Why is there no tendency to move forward or backward? Make a similar comparison with regard to the pressure on the right and left hand faces.

9. How does the pressure on the lower and upper faces compare? Is there any tendency to move the cube up or down as a result of the pressure of the water on these faces? Why?

10. Why must the buoyant force, or loss of weight in the water, be equal to the weight of the water displaced?

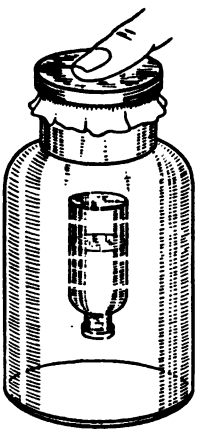
11. How may we easily find the weight of a bulk of water equal to that of a stone, or other heavy object?

Note.—The *Specific Gravity* of a substance is its weight compared with that of an equal bulk of water.

12. If a certain piece of ore weighs 8 ounces in air and 6 ounces in water, what is its specific gravity—or how many times heavier is it than water?

Experiment 4.—Find by actually weighing in air and in water the specific gravity of a piece of coal, brick, limestone, ore, iron, and other convenient substances.

13. How may the knowledge of specific gravity be useful to man?



Experiment 5.—Partly fill with water a small bottle having no cork; invert it in a large bottle filled full of water, covering the latter with a rubber film. The small bottle should contain just enough air to keep it suspended near the top of the larger one. Press on the rubber film and note the effect upon the small bottle.

14. How is the pressure from the finger transmitted to the water? How does it reach the air inside the small bottle?

15. What effect has this pressure upon the space occupied by the inclosed air?

16. How does this influence the specific gravity of the small bottle? Explain why it sinks and rises as pressure is applied or removed.

17. How does the "air bladder" in a fish enable it to sink or rise at pleasure in the water?

18. What principle enables submarine boats to do the same?

LESSON XXVII

EVOLUTION OF BOATS

1. What is the simplest form of water craft? Describe a raft and how it is used. Are rafts used at the present time?

2. What is the next higher form of water craft? Describe a canoe and a row boat. Make a miniature row boat.

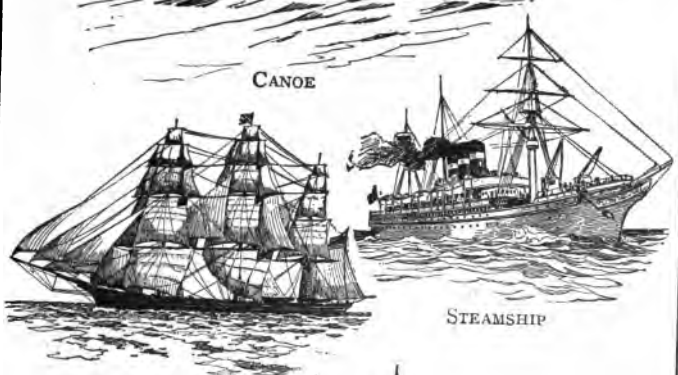
3. How does the canoe compare with the raft in ease of construction and handling? in speed? in carrying capacity?

4. What is the chief fault in using a raft? a canoe?

5. As boats become larger, what force of nature is used to aid man in moving them?

RAFT

CANOE



STEAMSHIP

SAILING VESSEL

WARSHIP

6. How are sails attached and held so as to catch the wind?

7. What can you say of the speed of sailing vessels? How long did it take Columbus to reach America on his first voyage?

8. What advantages have sailing vessels over canoes and row boats? Who use canoes and row boats now?

9. Describe the various kinds of sailing vessels and how they were rigged?

10. What is the greatest disadvantage of sailing vessels?

11. What force has largely displaced the wind in propelling boats and ships?

12. Who invented the first steamboat? Give an account of the *Clermont* and its first voyage.

13. What are the chief advantages of the steamboat over the sailing vessel?

14. How has the invention of the steamboat benefited the world?

15. Compare the first steamboats with the latest types and explain how greater speed and power have been obtained by various improvements in building them.

16. Describe, as you may have seen them, the various forms of steamboats made for different uses: e. g., launch, tug, dredge, coalers, freight boats, passenger boats, and different kinds of warships.

Note.—Get pictures of all kinds of water craft, both ancient and modern. Classify them as freight, passenger, and war vessels, and arrange them as nearly as you can to show the gradual improvements that have been made in each kind.

17. Compare ancient and modern warships.

18. Describe the battle of the *Merrimac* and the *Monitor*,

showing the advantages in construction each boat had over any other war vessels used before.

19. How has the *Monitor* been improved since the Civil War?

20. Describe a modern man-of-war; a torpedo boat.

21. What is the great advantage of a submarine boat?

22. How is it made to rise and sink in the water? How does a fish do this?

LESSON XXVIII

MODERN WATER CRAFT

TO THE TEACHER.—If the school is near a wharf where boats or ships of any kind may be seen, the class should make a visit there and, if possible, get permission to go aboard one of them. An obliging officer or sailor would make most useful explanations, which the pupils would never forget.

1. Describe any steamboat you may have seen or traveled in.

2. How long was it? how wide? what was its principal use? How was it propelled?

3. What advantage has the modern propelling screw over the old-fashioned paddle wheel?

4. How do sailors tell the speed they are going?

5. How do they tell in what direction the ship moves?

6. How does the captain tell where to steer the ship to escape rocks, shoals, and other dangers?

7. How is the depth of the water measured? How often do they measure it at sea?

8. What do you think the bottom of the ocean resembles? Have you ever seen a map of the ocean bottom? If so, describe it.

9. How fast do ocean liners travel?

10. What precautions are taken for the protection of the passengers in case of an accident?

11. Compare railroad and steamship travel—their safety, speed, cost, amount done, importance, etc.

LESSON XXIX

PROPELLING AND STEERING

1. How are rafts made to move in the water?

2. Describe the paddle and its use in moving and steering canoes.

3. Describe the oar as a lever. What are its advantages over the paddle?

4. How are oars used in steering a boat?

5. Why are not all vessels flat bottomed? Describe the advantages of each kind of bottom. Which is the easier to steer? Why? Which is used more in shallow water?

6. Why are some vessels still propelled by a paddle wheel? For what are such boats chiefly used?

7. How are most ocean steamers propelled? Where are the propellers placed? What advantages are gained by placing them there?

8. Which fin of a fish is used most in swimming? Where are the feet of a duck when being used to swim with?

9. Compare the position of the screws used in propelling ships to that of the parts used in swimming, of such animals as the duck, fish, seal, etc.

10. How does the screw propel the ship? Recall the work

done on the inclined plane. (Lesson 40, Fifth Grade).

11. Consider the wonderful power of so small a part as the screw.

12. How long does it take an ocean liner to travel from Liverpool to New York?

CORRELATED ART WORK
By Students of the State Normal Training School, Salt Lake City, Utah

13. How are canoes and boats steered? Are ships steered in the same way?

14. How do we steer a sled in coasting? Compare dragging the heel on one side of a sled in coasting with dragging an oar in the water on one side of a boat that is moving forward. What is the effect in each case?

15. Explain how retarding one side of a moving object will change its direction.

16. Describe the rudder and explain how it is used in steering a vessel.

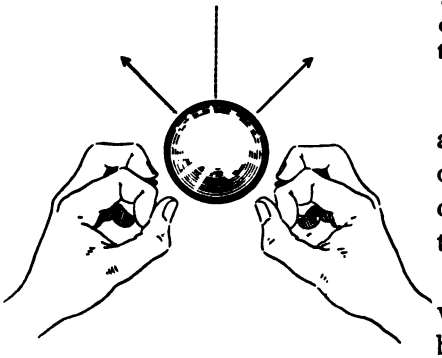
17. How may the sails be set to aid in making a boat go in the desired direction, different from that in which the wind is moving?

18. What experience have you had in steering boats?

LESSON XXX

RESULTANT MOTION

Experiment.—Suspend a light rubber ball by a long thread. Snap it at the same instant with one finger of each hand in directions that are



at right angles to each other. Observe the direction in which the ball moves.

1. How many forces act upon the ball? Why did it not move in the direction of either of them?

2. If both forces were equal, what would be the direction in which the ball would move? If one force were stronger than the other, what influence would it have upon the direction of the motion?

3. If a man rows a boat across a river at the rate of four miles an hour, and makes no effort to resist the current, which is three miles an hour, what will be the real direction he will take in crossing the river?

4. Draw a diagram showing the *intended* and the real course. Join the ends of the two lines and a right angled triangle will be formed with the real course as the hypothenuse. Draw lines parallel to the two sides of the triangle, making a parallelogram with the *real* course as the diagonal. This is called the *resultant* of the two forces.

5. Make a similar diagram of the forces and resultant in the experiment with the ball.

6. A weather vane on the top of a car moving south at the rate of 40 miles an hour will point in what direction? If an east wind, blowing at the same rate, also strikes the weather vane, in what direction will it point? Draw a diagram illustrating the two forces and their resultant.

7. What would be the resultant motion if the man in question 3 should row an hour down the stream? an hour up stream?

8. Roll a ball quickly across the table. Why did it not fall vertically when it reached the edge?

9. Give many other examples of motion that are the results of two or more forces acting at the same time upon an object.

10. What two forces often act upon boats in determining their path through the water?

Note.—An easy way to find the resultant of two or more forces is to think of them acting separately in succession.

LESSON XXXI

THE COMPASS

Experiment 1.—Lay a small bar magnet on a piece of wood floating on water.

1. In what direction does it come to rest? Does the same end always point northward?

Experiment 2.—Magnetize a steel knitting needle by rubbing it with a magnet, always in the same direction. Pierce with it two corners of a triangular piece of paper and suspend it from a long cord attached to the third corner. This arrangement permits the needle to hang horizontally and turn freely in all directions.

4. Will it come to rest with the ends pointing in the same direction each time?

5. Try to make it change ends and remain at rest. What is the result?

Experiment 3.—Bring the bar magnet near the suspended needle. Present in turn each end of the magnet to each end of the needle.

6. How does the north seeking end of the magnet affect the north seeking end of the needle? the south seeking end of the needle?

7. Experiment with these until this law of magnets is discovered.

Experiment 4.—Break in two the magnetized steel knitting needle and see if each piece will have two poles.

Note.—At the right time the teacher may explain that the earth is supposed to be a great magnet with one end or point of attraction near the North Pole and the other near the South Pole.

Experiment 5.—Heat the needle and see if it retains its magnetism.

8. How may a magnetic needle be arranged to indicate the point of the compass?

9. Examine a compass and see how it is constructed and how it acts.

10. Of what use is the compass to the mariner? Why do sailors use it more than other people do? Discuss its many uses.

LESSON XXXII

DANGERS OF NAVIGATION

1. Mention all the dangers to navigation that you can think of. Are they greater than those of railroad travel?

2. How may a hurricane injure a ship?

3. What precautions are taken on board against an approaching storm?

4. Why are the boilers and heavy machinery placed near the bottom of the ship?

5. How does a heavy ballast in the hold of a vessel prevent capsizing?

Experiment.—Stand a cardboard box, or an empty chalk box, on end. Try to tip it over. Now place a heavy paper weight in the bottom and try to tip it over.

6. Explain the effect of the weight upon the stability of the box.

7. Why are seamen sometimes lashed to parts of the vessel? Tell what you know of the power of waves. Compare it with the power of wind.

8. What damage have you seen done by wind? by waves?

9. How does fog make navigation dangerous? Does it affect travel on land in the same way?

10. What precautions are taken by seamen during a fog? Tell what you can about the fog horn, bells, searchlight, etc., and how each is used to insure safety.

11. How do sailors guard against running onto rocks, shoals, and similar dangers? Examine a chart or map of the sea bottom.

12. Why and where are lighthouses built?

13. What happens to a ship if it strikes a rock and a hole is made in the hull?

14. Why are passenger vessels often built with airtight compartments in the hull?

15. What precautions are taken to prevent collisions with other vessels, icebergs, wrecks, etc.?

16. Why is the depth of the water frequently measured?

17. Why are there so many lifeboats on every passenger vessel? Describe them and their uses.

Note.—Printed directions are placed in the room of each passenger,

directing the inmate where to go and which lifeboat to take in case of accident.

18. Discuss various kinds of buoys and danger signals and their uses.

19. Why are so many life-preservers seen in various parts of the vessel? Describe one or two kinds and tell how they are used, under what circumstances, and how they prevent drowning.

20. Why does a pilot take charge of a ship before entering a port?

21. Describe a wreck you may have seen or learned about.

22. How is wireless telegraphy used in case of an accident at sea? Give examples where it has saved many lives.

LESSON XXXIII

LIFE SAVING STATIONS

1. Where there is so much sea traffic as is carried on along our coasts, especially the Atlantic coast, wrecks occur quite often. What efforts has the government made to prevent such accidents and to rescue the shipwrecked passengers near our coasts?

2. About how many life-saving stations have been established?

3. What determines their location? Can you tell where any of them are situated?

4. Describe the equipment of such a station. If possible, visit one and learn all you can about it.

5. Compare it to a city fire department.

6. What lookout is kept for wrecks? In what kind of weather do most wrecks occur?

Note.—Men patrol the beach night and day and give instant warning in case they discover a wreck.

7. Describe the manning and launching of a lifeboat when a wreck signal is received at a station.

8. When a ship has struck a rock near the shore, and the breakers are too strong to permit the boat to reach it, how is a life line made to reach the ship?

9. Describe the method of rescuing passengers with a life line.

10. Give an account of any wreck you know about and efforts made to rescue the passengers and crew from their peril.

11. What can you say of the skill and courage of the men engaged in this dangerous work?

12. Find, if you can, the number of lives saved by the life-saving stations of the United States in any one year.

LESSON XXXIV

THE SPECIAL SENSES

1. Mention all the colors you can easily recognize and name. Make a list of them. Name, in their order, the colors of the rainbow.

2. Point out and name all the colors that may be seen in the schoolroom.

3. How many colors, tints, and shades do you think you can recognize?

Experiment 1.—A ray of light admitted through a small hole in a window shade, and made to fall on a glass prism can be separated into the colors of the rainbow. The room should be made as dark as possible.

4. Can all persons recognize colors accurately? Have you ever seen persons who were color-blind?

5. Darwin concluded from experiments that many insects could discern only certain colors. Infer from this a purpose in coloring flowers.

Experiment 2.—Try to match colors. Compare colors seen in the room with others seen elsewhere and judge whether they are alike or in what respects they differ.

6. Can the ear discern as many different sounds as the eye can recognize different colors?

7. How many odors can you name?

8. How many flavors can you taste and recognize distinctly?

9. Compare the range of the sense of touch with that of the other special senses.

10. Consider the range of each of the five senses and tell which you think is most highly developed.

11. Consider the many uses to us of each of our senses.

12. Describe the many inconveniences of the blind; of the deaf.

13. Which sense would cause you the least detriment if destroyed?

14. Suggest habits that will improve each of our special senses.

15. Compare those powers in animals with our own. Which can smell better than man? Why do the dog, the deer, the buzzard, and other animals you know, have a keener sense of smell than man has? How does it serve their needs?

16. Name animals that have a keener sense of hearing than man has. What evidence of this have you seen in any animal? Have you ever noticed a woodpecker rap the bark of a tree and then wait as if listening to hear the disturbed worm underneath move?

17. Can any animals see farther or better than we can? Why must the eagle be able to see a great distance? Tell what you know of the eye-sight of the cat, owl, horse, and other familiar animals.

18. The eyes of many of our song birds magnify. Why?

19. What sense highly developed takes the place of sight in the earthworm? in the fish of the Mammoth Cave?

20. What evidence have you seen that animals have a sense of taste? Do you know if taste is ever remarkably developed in any of the lower animals?

Note.—In man all these senses are capable of very high development. Many physicians have a very sensitive touch attained through much practice. Sailors become able to discern a sail or other object at great distances. A government pomologist claimed to be able to distinguish any variety of apple blindfolded, by the sense of smell. Many chemists also develop this sense remarkably through use. Grades of tea are distinguished by professional "tea tasters;" and we all know how skillful becomes the ear of the musician in discerning harmony and discord.

LESSON XXXV

COLOR IN NATURE

1. For what purpose is color used in nature?

2. How does color contribute to our pleasure? to our needs? to our safety? Illustrate each with as many examples as you can think of.

3. Do animals use color in any respect as man does? State what evidence you have seen of this.

4. Does color aid animals in distinguishing proper food? in discovering an approaching enemy? in detecting the presence of danger? Illustrate your answers with examples you have seen.

5. Do animals enjoy colors? What evidence have you that they do?

6. Account for the beautiful plumage of birds, especially that of the male. What attracts insects to flowers?

7. Do colors ever cause disagreeable feelings, as anger, or fear, in animals? Give examples.

8. How may an animal's color protect it from its enemies? Give illustrations from your own observations.

9. Mention animals you have found living chiefly upon grass and foliage—such as lice, slugs, and worms. What is their color? How does it protect them? Would they be as safe as if they were red? Why?

10. Name animals that are found on the bark of trees and that perch on large limbs. What color prevails among them? Why?

11. Why do the mountain hare, weasel, and other animals of the north temperate zone change their color to white in winter?

12. Account for the color of the polar bear.

13. Why is the tiger striped? the leopard spotted? the frog green? the toad dirt colored? the mountain trout speckled? the lion tawny?

14. Think of other animals in whose color there is a purpose.

15. Find a reason for the two colors of certain fishes and birds seen on the upper and under parts of their bodies.

16. What uses do plants make of colors?

17. Why is most unripe fruit green in color? How came these two words, *green* and *unripe*, to mean the same when applied to fruits and vegetables?

18. Why do many fruits take on brilliant colors when they become ripe? Recall the work on seed distribution. (See Lesson 9, Third Grade).

19. Account for the beautiful colors of flowers.

20. When do the pretty petals fall and a green calyx cover the young seeds? Why?

21. Night-blooming plants are generally of what color? Why?

22. Why are the twigs bearing the early fruit buds generally a dark purple color, while other branches may be a light green?

Experiment.—Place two pieces of cotton cloth, one white and the other black, on the snow in the sunshine. Which sinks into the snow the more rapidly? Why?

23. When orchardists fear a frost will injure the early buds if they develop too soon, why do they spray them with whitewash?

Note.—Spraying trees with whitewash will keep their temperature several degrees lower than unsprayed ones, thus retarding their development.

LESSON XXXVI

INFLUENCES OF CLIMATE

1. Compare the weather now with that of three months ago. What will it be three months hence?

2. Describe the weather of this latitude during each of the

four seasons. Consider the average temperature, rainfall, wind, sunshine, etc. Get what information you can from your own observations and records.

3. Compare the climate here with that in the far north; in the far south.

4. Mention five plants growing in the frigid zone. How many can you name growing in the tropics?

5. What can you say of the amount and kinds of vegetation in the frigid zone? in the torrid zone?

6. What is the chief agent that fixes plant life in the different zones?

7. How does weather affect the rapidity of growth in plants? Where does vegetation grow slowest? Where does it grow most rapidly?

8. What is the fastest growing plant you know? How much will it grow in a day? a week? a season?

Note.—The bamboo of India, by actual measurement, has been known to grow half an inch an hour or a foot a day, during the rainy season. (Stoddard's Lectures on India, page 44).

10. Where do plants reach their greatest size?

11. How do the animals of the three zones compare in number? in size?

12. Does climate control animal life as well as it does vegetable life? Give proof of this.

13. Make a list of all the animals you know belonging to the frigid zone. Are they large or small, generally? Does the list include many insects? Why?

14. Where do we find animals of the greatest size, the greatest numbers, and the greatest variety?

15. How do the animals of the north keep warm?

16. Why are so many of those of the south naked?

17. What do those of the far north eat mostly? Why?

18. Make a list of all the animals you know that are found in the torrid zone; in the temperate zone.

19. How are animals affected by a change of climate? Do animals from either of the other zones live long when brought to this zone?

20. Which seems best fitted for man's use? Give a reason for your answer.

21. Compare the isotherms and rainfall of the three zones and explain their effects upon animal life and plants.

Note. The same influences that control conditions of plants and animals at home during the year, produce similar results over the whole face of the earth.

LESSON XXXVII

SURFACE CHANGES

To the Teacher.—Take the class for a field lesson where the pupils may see surface changes of various kinds taking place in nature. Study a creek bed; a wash or gully; the shore of a pond, lake, or sea; or a canyon gorge. If no better place can be found, take the pupils out on the campus or on to an unpaved street just after a heavy rain, and show them how the rains move the soils. Modify the following lesson to fit the observations of the pupils.

1. Observe the effects of the rain upon the surface of the ground.

2. What makes the streams of rainwater so muddy?

3. Where does the rain wear the deepest runnels? Why? Consider the slope, the kind of soil, the surface drained by the runnels.

4. Do you know of a gully or ravine that was washed out by the rain? Describe it.

5. What kind of soil washes most easily? least easily?

6. Is any elevation nearby growing less? Is any hollow being gradually filled up?

7. Is any river bank in your neighborhood being undermined by the water, and caving in?

8. Do you know of any stream that has changed its course

WATER EROSION

at all recently? Have any islands been formed in any of them?

9. What becomes of the sediment that is carried by the streams? What effect has this loss upon the higher lands?

10. Have you ever seen a miniature delta?

11. What kinds of sediment are carried farthest? Which

is dropped first? Why are deltas composed of finest soil?

12. Have you seen the shore of a pond or lake changed in any part by the settling of silt carried into it by streams?

13. What great changes are taking place in our national coast line from this cause?

Note.—The coast of Louisiana is growing out into the Gulf of Mexico from a foot to a rod each year. New Orleans is considerably farther from the Gulf now than when it was founded.

14. Scientists say that the Gulf of Mexico once extended northward as far as the mouth of the Ohio river. Explain this.

15. Whence came the soil that now fills the lower Mississippi valley?

16. What mountains seem to be much worn?

Note.—The Height of Land in Southeastern Canada is said to be the oldest mountain range in the world. How do scientists reach this conclusion?

17. How may we tell old mountains from new ones?

18. Suppose the materials in the Height of Land, the Appalachian mountains, and the Rocky mountains were about equally hard, which would you conclude were the oldest? the newest? Why?

19. What has become of all the dirt washed down from these mountains?

20. What other agent wears away or removes surface forms?

21. Tell what you know of sand dunes and their changes.

22. Where have you seen stony formations cut away by the sharp particles of sand carried in the wind?

23. How is a sand blast used in etching glass?

WIND EROSION

24. Do you know of any other agents that change the surface of the earth?

LESSON XXXVIII

KINDS OF ROCKS

1. Have you ever seen sand or soil hardening into stone?

2. Have you seen rocks that show indications of having been formed of sand or mud? Examine the samples in the school cabinet and select all such stones.

3. Can you suggest how they became hardened into stone?

4. Describe the making of the common mortar used in bricklaying.

5. Tell how sidewalks are paved with cement.

6. What agent hardens the sand in each case?

7. How can you distinguish rocks that have been formed from sediment?

8. Why are they generally in layers or strata?

All such rocks are called *sedimentary*, or stratified.

9. Where have you seen sedimentary rocks in great masses? Observe and collect samples of sedimentary rocks. Learn to recognize and name the various kinds of sandstone, limestone, and shale.

10. Have you seen rocks that resemble the clinkers from the furnace, or the slag from the smelter?

11. Select from the cabinet all the samples that show such action of fire. Distinguish and name samples, e. g., lava, porphyry, basalt, pumicestone, etc.

12. In what respects do they differ from stratified rocks?

13. Rocks that show evidence of having been thrown out of a volcano in a melted state are called *igneous* rocks. For what purposes are they used?

14. Where have you seen igneous rocks in nature? Do they disintegrate easily?

Experiment.—Heat a small piece of limestone in the flame of an alcohol lamp with the aid of a blow pipe. Note the change it undergoes.

15. What effect has it upon bricks to burn them? How are the hardest, or clinker, bricks formed?

16. Examine stones that have been highly heated in a

stove or furnace. What change, in appearance, has the heat wrought?

17. Have you seen any rocks in nature that seem to have been changed by the action of the heat?

Such rocks are called *metamorphic.*

18. Are they stratified? Do they have a distinct cleavage?

19. Collect samples and examine the structure of granite, marble, quartzite, mica, schist, etc.

20. Tell what you know of the use of each; their source of supply, and the properties which make them valuable.

LESSON XXXIX

LIMESTONE—ORIGIN

Experiment 1.—From the school collection test samples of many kinds of stone by pouring a small amount of hydrochloric acid upon each. Effervescence indicates limestone. A small bit of limestone dropped into a test tube containing strong vinegar also will produce effervescence. This is a common and simple test for limestone.

1. Can you scratch limestone with your finger nail? With your pocket knife? How does it compare in hardness with other common rocks?

2. Is the color of limestone uniform?

3. Infer from specimens, or better, from a visit to a limestone quarry, whether limestone was formed under water.

4. Examine a piece of limestone under a lens. Describe its appearance.

Experiment 2.—Weigh a piece of limestone carefully and then heat it red hot. When cool, weigh it again.

5. Has it changed in weight? How much?

6. Has it changed in color? in hardness? in appearance?

Roasting limerock makes quicklime. If possible, visit a lime kiln and see how the lime used by builders is made.

Experiment 3.—Wet quicklime with a little water and describe what happens.

7. What produces the heat? Can you think of any other ways of creating heat without fire?

8. For what is lime used?

9. Can quicklime be made from other things than limestone?

Experiment 4.—Test oyster shells and coral and other seashells with hydrochloric acid. Also heat fragments of them red hot and moisten them to see if burning them turns them to quicklime.

10. Since most limestone is found in mountainous regions, how do people on the low, sandy coasts procure the lime necessary for building purposes?

Note.—Seashells in great quantities are burned into lime for commercial purposes in the Gulf states and in other places near the ocean where shells are abundant.

11. Have you ever seen fossils found in limestone formations? Were they land or water organisms?

12. What do those things tell us concerning the origin of limestone?

13. How are coral islands formed? 20,000 square miles of the United States was made by the little coral animal. Which state is built mostly of this kind of limestone?

Note.—Much of the limestone of the earth's surface was secreted from the waters of the oceans by very small animals called foraminiferae, much as coral reefs are formed from the shells of the coral polyp.

LESSON XL

LIMESTONE—KINDS

1. As you have opportunity, collect samples of as many kinds of rock and mineral formation as you can for the school cabinet. All the varieties mentioned here should be found in the cabinet.

2. Describe *common limestone.* In what colors have you seen it? Is it heavy, compared with other stones? Has it a fine or coarse texture? What is its degree of hardness? Can it be polished?

3. Where is the nearest limestone quarry? If possible, visit it and study the formation as well as the methods of quarrying the stone.

4. Mention as many uses of limestone as you can.

5. Describe *chalk* (not school crayon). What is its color? Scratch it with the finger nail. What is its degree of hardness? Is it light or heavy compared with other minerals?

6. Examine small particles of it under a good microscope, and describe its structure.

7. Where is chalk found? For what is it used?

8. Compare samples of various kinds of *marble.*

9. Examine a broken surface with a magnifying glass. Describe its texture. Do you think it has been changed by the action of fire?

10. What properties make marble valuable, and for what purposes is it used?

11. *Calcyte* is generally whitish in color, quite heavy, and hard. Like marble, it is crystalline in structure. Test a piece with acid.

Experiment 1.—Silica stones may be distinguished from limestone by the peculiar odor emitted when they are struck a violent blow with another stone or a hammer.

12. Examine samples of *stalactites* and *stalagmites* and find out how they are formed.

Some samples are very beautiful—especially a cross section, when polished.

13. *Dog-toothed Spar* is made up of lime crystals, usually in dense clusters on the outer surface of a stone. How are salt and other mineral crystals formed?

SIXTH GRADE—SPRING WORK

THE GLADNESS OF NATURE

Is this a time to be cloudy and sad,
When our mother Nature laughs around;
When even the deep blue heavens look glad,
And gladness breathes from the blossoming ground?

There are notes of joy from the hang-bird and wren
And the gossip of swallows through all the sky;
The ground-squirrel gayly chirps by his den,
And the wilding bee hums merrily by.

The clouds are at play in the azure space,
And their shadows at play on the bright green vale,
And here they stretch to the frolic chase,
And there they roll on the easy gale.

There's a dance of leaves in that aspen bower,
There's a titter of winds in that beechen tree,
There's a smile on the fruit and a smile on the flower,
And a laugh from the brook that runs to the sea.

And look at the broad-faced sun, how he smiles
On the dewy earth that smiles in his ray,
On the leaping waters and gay young isles;
Ay, look, and he'll smile thy gloom away.
—WILLIAM CULLEN BRYANT

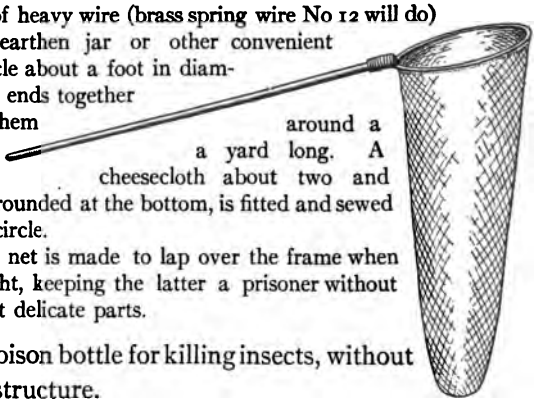
LESSON XLI

INSECTS

TO THE TEACHER.—As soon as insects begin to appear in the spring, the children should be directed to study them. An insect net, a poison bottle, a larvæ box, and some suitable place to preserve specimens should be provided. Field lessons and excursions should be taken where the insects may be seen under natural conditions and their structure and relations studied.

1. Make an insect net according to directions.

Bend a piece of heavy wire (brass spring wire No 12 will do) around a large earthen jar or other convenient object, into a circle about a foot in diameter, twisting the ends together and wrapping them around a wooden handle a yard long. A bag of tulle or cheesecloth about two and a half feet deep, rounded at the bottom, is fitted and sewed around the wire circle.



In using it, the net is made to lap over the frame when the insect is caught, keeping the latter a prisoner without injury to the most delicate parts.

2. Make a poison bottle for killing insects, without injuring their structure.

Put a few lumps of cyanide of potassium into the bottom of a wide mouthed bottle. Cover the lumps with sawdust, and pour in plaster of paris mixed with water to the consistency of cream, making a layer about a quarter of an inch thick. The plaster will harden in a few minutes. A tightly fitting cork should be used. A disk of blotting paper may be placed over the plaster and changed as

often as needed for cleanliness. An insect dropped into this bottle will die almost instantly and seemingly without pain. A proper label should be placed on the bottle, as the fumes are poisonous to man as well as to insects.

3. Collect and preserve in any convenient way, samples of as many kinds of insects as can be obtained near the school.

4. Study the specimens and classify them into groups according to some leading characteristic of structure or habit. For example, group together and make a list of all insects: (a) found in the household; (b) found in the garden; (c) found in the field; (d) found in the water; (e) beneficial insects; (f) injurious insects; (g) winged insects; (h) wingless insects, etc., etc.

5. Note where various ones are found. Which are found on leaves? in cracks or crevices? under boards or stones lying on the ground? flying in the air?

6. Discover how different insects eat and what they eat.

7. Examine with a lens the mouth parts of different insects, if possible, when they are eating, and note how they are used.

8. What does a grasshopper eat? Describe its mouth parts.

9. Allow a mosquito to rest on your hand while you watch it with a magnifying glass draw its tiny meal of blood. Describe the mouth parts of the mosquito; of the house fly; of any common insects you may be able to observe and report to the class what you learn.

10. Note the work of insects; bring to the class samples of

fruit, leaves, bark, wood, etc., that have been insect eaten; also bring any evidences that you may find of the good that insects do.

LESSON XLII

INSECTS (Continued)

1. How many legs have insects? Do all have the same number?

2. Examine their feet and claws with the aid of a good lens. How do flies walk on glass in any position?

3. What insects crawl? hop? swim? run? Explain how each is adapted to move in its peculiar way. Make lists of all the insects you can think of that move in these ways.

4. In how many ways do insects defend themselves? Which bite? Which sting? Which have a protective armor or covering?

Note.—Ammonia and bi-carbonate of soda moistened, are common remedies for the sting of insects, applied to the parts affected.

5. Which insects are protected by their color? by their form?

6. Which emit an odor that serves as a protection?

7. Which depend upon their nest, web, or some nearby place of concealment for protection from enemies?

8. Before disturbing any insect you discover, notice if it is eating, hibernating, or laying eggs. Do not hasten or you will see little. Make notes and drawings as you observe.

9. What insects are rare in your neighborhood? Why? Which have been more abundant than they are now? Can you account for their decrease?

10. What insects are numerous in your vicinity? What advantages do they have over rare ones? Consider structure, food, enemies, means of escape and defense, rate of increase, intelligence, length of life, etc., of both kinds.

11. What insects often become so numerous as to be a nuisance? Which are often an actual danger to man? Give examples that you know.

12. Tell what you know of methods men take to kill or protect themselves against house flies, mosquitoes, grasshoppers, and any of the garden, field, and orchard pests.

Note.—The Department of Agriculture at Washington, D. C., issues free many bulletins on insect pests which may be obtained by applying to the Secretary of Agriculture. Many states also have experiment stations that send out similar literature free.

13. Write, from your own observations, what you know of the life history of any one of the common insects found near your school or home.

14. Make collections of specimens that will illustrate the different stages through which any of the common insects pass.

15. In which stage are most insects most injurious to man?

16. In which stages do the useful ones mostly render their services?

17. Draw a bee; a beetle; a butterfly.

LESSON XLIII

RELATION OF INSECTS TO PLANTS

Experiment.—Cover one cluster of flower buds with netting to keep off the bees and other insects, leaving another similar cluster on the same

plant uncovered. The blossoms of the crimson clover, strawberry, or any of our common orchard fruits may be used. When the blossoms have developed their seeds, count those found in each cluster and put them in separate bottles properly labeled.

1. Notice any difference in the relative number, weight, size, and appearance of the two bottles of seeds.

2. Continue the experiment and test a given number—say 50—of each of the seeds to see how many of each kind will germinate.

3. If the crimson clover is used, the seeds may be gathered before the school closes in the spring and planted in the following spring. In this way the value of both kinds of seeds may be definitely determined and compared during a year.

4. When able to infer from the foregoing experiments and other observations, tell if insect visits to flowers are beneficial or hurtful.

5. What inducements do flowers offer to bees and other insects? Consider their color and beauty, their odor, their nectar, their position on the plant, the time of blooming, and the shape of the flower, to accommodate the visitor. Illustrate each point with an example.

6. Study the parts of the flower and the office of each part.

7. What usually protects the flower until it opens? Describe the sepals, and the calyx which they form. How do they protect the flower? Consider their color, thickness, position, fuzz, hair, etc.

8. What becomes of the calyx when the flowers have bloomed?

9. Account for the petals. What is the most common color among flowers?

10. What is the color of flowers that bloom at night? Why?

11. Why do some bloom at night while most flowers are closed?

12. Study the stamens. Note their position, size, parts, etc.

13. Note the bursting of the anther, or pollen box, and the scattering of the pollen.

Experiment.—Shake some pollen dust from a sweet pea or other common flower upon a piece of blotting paper. Moisten the paper with a weak solution of sugar and keep it quite warm for a few hours. With the aid of a microscope the grains of pollen may be seen to germinate.

14. Describe the pistil and its relations to other parts of the flower.

15. How will the visit of the bee to a flower bring pollen in contact with the pistil? Note its connection with the ovary, or seed box.

Note—When pollen grains fall on the tops of the pistils and germinate, they render the seeds in the ovary fertile.

16. Observe various flowers and infer how each becomes fertilized. Which kind depends upon insects? Which upon the wind? Which have their parts so arranged that the pollen will distribute itself upon the pistils?

17. What influence has the pollen used to fertilize a seed upon the quality of fruit it produces?

18. Should squash and muskmelon be planted near each other? Have you ever seen two kinds of kernels on the same ear of corn? Explain.

19. How is this principle used in securing new varieties?

20. Why is it necessary to "bud" fruit trees to insure the fruit to be true to name?

LESSON XLIV

HARMFUL INSECTS OF THE HOUSEHOLD

1. Mention insects that are harmful or annoying to man. Make a list of those that enter our houses.

2. What means do we use to get rid of the common house fly? Consider door and window screens, fly traps, fly papers and poisons, electric fans, etc.

THE COMMON HOUSE FLY

3. In what ways are flies an annoyance? In what ways may they be dangerous?

4. Where do flies hatch, and under what conditions? Give an account of the life history of the house fly.

5. What effect will strict cleanliness about our premises have upon the number of house flies that will be hatched?

6. Tell what you can of the life and habits of the mosquito. In what ways is it a nuisance? in what way, a danger?

Does this foot of the common fly suggest how it walks on the ceiling or window pane?

Experiment.—A colony of mosquitoes can be reared with little trouble at home or at school. Almost any stagnant pool or vessel of water standing out of doors in the summer time, will be supplied with mosquito eggs or wrigglers. Fill a large glass jar with such water and tie a piece of netting over it to prevent the mosquitoes from escaping when hatched, and the metamorphosis may be studied at leisure.

A small fish placed in the water would illustrate a natural enemy, and a small quantity of kerosene oil poured on the water would show an artificial way of destroying them.

7. In a similar way study and report upon other insects and small animals that intrude into the home of man, e. g., the roach, the clothes moth, the flea, etc. Consider in each case their growth, or life history, the injury they do, and the best methods of getting rid of them.

8. What insects attack man in tropical countries? Tell what you know of such insects and how the people there protect themselves from injury.

9. Are the people in the northern countries troubled as much with such insects?

10. Why are there more kinds and greater numbers of insects in the tropics than in the other zones?

LESSON XLV

HOW ANIMALS AND PLANTS AID EACH OTHER

1. In how many different ways do animals aid plants?

2. Name animals that aid plants in some way, and tell how they do it.

3. Which animals distribute the seeds of plants? In how many different ways do animals do this work? Give examples you have seen.

4. Why does the plant need to have its seeds scattered?

5. Do the animals, in doing this work for the plant, receive any benefit from the plant? Tell how the animals are induced to scatter the seeds of plants.

5. Name all the animals you have seen working in the flowers and probably fertilizing them.

6. What benefit do they get from the flower while doing this work?

7. What animals aid in preparing the soil for the growth of plants? (Recall Lesson 56, Fourth Grade, on the Earthworm).

8. Do plants in turn furnish anything to the earthworm?

9. Make a list of all the animals you know that live on plant food. These are often called *herbiferous* animals.

10. Try to think of some good that each of these animals does to some plants.

11. Which plants furnish animals with fruits to eat? Which furnish them with edible seeds? leaves? bark? stems? roots?

12. What, besides food, do plants furnish animals?

13. In what ways are the animals provided with shelter by plants? Mention parts of a plant that different animals use for shelter.

14. What animals protect some plants from being destroyed by other animals?

15. What would, probably, be the effect upon the plant kingdom if all animals should die?

16. What would, probably, be the effect upon the animal kingdom if all plants should die?

17. Which seems to be the more dependent upon the other?

18. Which was probably created first? Why?

19. What has man done to improve plants? What reward does he get for his labor and skill?

Experiment.—Plant in different parts of the school garden seeds of the same kind. Neglect one part, and cultivate with care the other, and note the differences in results.

20. Tell what you have observed of the effects of care and

cultivation upon plant growth. Also give illustrations of neglected gardens, fields, and orchards.

21. In what ways do plants aid man? Consider what they furnish for food, clothing, shelter, fuel, implements, and useful materials.

22. Name the plants that furnish each of the necessaries named. Give many examples.

23. Observe lawns, gardens, orchards, and fields, and report which are well cared for and which are not.

LESSON XLVI

GERMINATION

Experiment 1.—(a) Plant some seeds of beans, peas, squash, corn, wheat, or other large seeds in a shallow vessel of clean sawdust and keep them warm and moist. At the same time a few may be planted of each kind, in pots of soil, or in the school garden. Those in the sawdust may be examined without soiling the hands, and each stage of their development observed and recorded.

(b) Or a glass tumbler, lamp chimney, jar, or still better, a box with glass sides may be filled with sawdust, moss, or even garden loam, and seeds planted next to the glass, where their changes may be seen at any time by the pupils.

1. What is the first change that takes place in the seeds? Why does the coat of the bean or pea, for example, first wrinkle and then get smooth? Account for the swelling of the seeds.

2. What happens when the seeds swell to a certain limit? Why are they softer? Where does the coat break open?

3. Which appears first, the stem or the root? Which grows the faster?

4. What change takes place in the size of the seeds as growth proceeds? Account for this.

5. What direction does each take? Does the position of the seed determine this?

Experiment 2.—After the stem and root have begun to grow in their accustomed direction, invert one of the young plants, and watch the result. A potted plant turned on its side for a few days will begin to change the direction of its stem.

6. Describe the different stems. Note how they break through the soil. Which pierce the soil with a pointed stem? Which break through with a loop of the stem?

7. Which plants lift their seeds above the surface? Which do not?

8. Which seeds contain no seed leaves? Which seeds, when they begin to grow, furnish the first pair of leaves for the young plant? Examine many different kinds of seeds and find out which are made up of two similar halves and which consist of a single compact body. The first are called *dicotyledonous* and the second *monocotyledonous* seeds. Make a list of each kind.

9. Which kinds can pierce the surface of the soil with ease? Which find it more difficult? Which can be planted deeply? Which must be planted near the surface?

10. Examine the roots with a magnifying glass. Note the root hairs. Infer their use.

11. Taste some of the seeds that have begun to grow. Compare with the taste of the same kind of seeds that have not yet germinated. Account for the sweetness developed in the growing seeds.

12. What change takes place in most of the seeds as the plants continue to grow?

13. What part of the seed furnished the stem and root? This is called the *germ*.

14. What is the purpose of the rest of the seed?

Experiment 3.—Crush samples of the same kinds of seeds used in Experiment 1, mix with a little water in a test tube, and add a drop or two of tincture of iodine. A dark purple color indicates starch. Repeat the experiment with a sample of starch: then use sugar, soda, or other substance at hand. Also test scraped potato, beet, etc., and determine which vegetables contain starch.

Experiment 4.—Try to dissolve in water a small quantity of starch in one test tube and some sugar in another. Note the difference. Why is one liquid transparent and the other not? Pass both through a filter paper; taste each after filtering.

15. Which dissolves in water? Which only mixes? Why does the filter catch the starch and not the sugar?

Note.—Sugar is soluble, but starch is insoluble, in cold water. It remains in small particles floating in the water.

16. Why does the parent plant store up the food in the seed for the young plant in the form of starch?

17. Why would it not be as well to store sugar in the seed as to store starch?

18. Which do you think would circulate better through the tissues of the plant? Which passed through the filter better?

19. What would be the effect of winter storms upon the seeds of wild plants if the stored food were soluble in water?

Note.—The warmth, moisture, and other conditions favorable to germination are such as to convert the starch in the seed into sugar, which is dissolved in the water and carried to the different parts of the plant just as it is needed. By the time the starch in the seed is all used up, the roots are big enough to draw food from the soil,—a very happy provision of nature.

20. Why should the biggest and best seeds be used in planting?

LESSON XLVII

PLANTS NEED AIR

Experiment 1.—Place a few grains of wheat in each of two shallow vessels. Cover entirely with water the seeds in one vessel, and only moisten well the other seeds. Cover each with a glass tumbler to prevent evaporation and keep them in a warm place for two or three days.

1. Which seeds germinate? Which do not?

2. Both have warmth and moisture. Does one lot of seeds have something that is kept away from the other? What?

Experiment 2.—Partly fill two tumblers with clay loam. Plant a few seeds of beans and peas in each, keeping one moderately moist, while the other is kept very wet. Let both remain in the same temperature and note results.

3. How does the air find its way to the seeds and roots in the first tumbler? As the water evaporates little by little from the soil, what takes its place in the soil?

4. How is the air kept away from the seeds and roots in the second tumbler?

5. Have you ever seen bubbles of air arise from the water poured on a potted plant to irrigate it or from the ground as an irrigation stream passed over it? Whence comes this air?

6. Explain the interchange of air and water in the soil.

7. Why is a long rainy spell detrimental to crops, especially on land that is poorly drained?

8. Is there ever danger of over irrigation in the arid regions?

9. How does plowing affect the air in the soil?

10. What kinds of soil seem light and filled with air? What kinds are soggy and dense? Which is best for plant growth?

LESSON XLVIII

PLANTS NEED WATER

Experiment 1.—Remove a plant from the moist soil or sawdust where it has been growing, and lay it on the table a short time. What happens to it? Place the roots in water a short time and note the change caused.

1. In moving plants why must the roots be kept constantly moist?
2. Why do cut weeds so quickly wilt?
3. What effect has a drought on the appearance of plants?
4. What becomes of the water taken up by roots of plants? Can you think of an experiment to prove this?

Experiment 2.—Invert a fruit jar over a growing potted plant (see Lesson 56, Grade 5, page 201) and account for the water collected on the inside of the jar.

Note.—A sunflower standing 40 inches high was found, by experiment, to give off a pint and a half of water every day. A cabbage exhaled a pint a day. To mature a crop of wheat of 30 bushels to the acre, 14 to 25 inches of water are required according to the nature of the soil.

Experiment 3.—Lay off three small pieces of ground in the school garden. After a rain cover one with a mulch of old straw; rake or roll the surface of another; and allow the third to remain untouched. After a few days of dry weather, test the moisture in the soil on each piece of ground. Find out which retains the moisture longest.

5. What is the first indication that a plant is suffering for water? Which way does the leaf curl? Infer a reason for this.
6. If drought continues, what is the next thing the plant does? How does dropping some of its leaves aid the plant? Which ones fall first? Why?

7. What kinds of soil absorb water best?

8. What kind of soil retains water longest? (Recall work done in Lesson 46, Fourth Grade.)

9. What crops require much water?

10. What crops grow with but little water?

11. Where, in the United States, is the rainfall greatest? Where is it least?

12. Tell how this influences crops.

13. What substitute for rainfall is used in the arid regions?

14. Describe methods of irrigation as far as you understand them, and the advantages and disadvantages of irrigation.

15. How may the surface of the soil be prepared so as to retain longer the moisture received from irrigation or rain?

16. Where rains are excessive, what damage is done to crops? Tell what you know of the draining of lands that are too wet.

LESSON XLIX

PLANTS NEED WARMTH

1. When do most seeds germinate? Why?

2. Observe throughout the year, and see in how many months of the year some seeds may be found germinating.

3. When do the buds on trees burst and plant life take on its greatest activity?

4. What is the chief cause of this?

5. When does this activity almost cease each year? Why?

6. Compare the variety and abundance of plant life in the valley and on the high mountains. Compare the temperature also.

7. Compare the vegetation in the three zones.

8. What is the greatest factor in determining the kinds and quantity of plant life in any particular place?

9. Suggest an experiment to show the need plants have for warmth. Perform it.

10. Will warmth alone make plants grow? Name the four great essentials for plant growth.

11. What kinds of soil are warmest? (Recall Experiment 1, Lesson 47, Fourth Grade.)

12. Which kind absorbs most heat from the sun?

13. Does science approve the expressions, "As cold as clay" and "burning sands?"

14. If you wished to raise the earliest strawberries for market, would you choose a garden with sandy soil or clayey soil?

Experiment.—Test the temperature of the soil in different places on the campus, and at various depths, and account for any difference you may discover.

15. Does the color of the soil influence at all its temperature?

16. At what season of the year are white dresses, straw hats, and light colored clothing mostly worn?

17. When do we wear dark clothing?

18. Does the law "black absorbs and white reflects heat," apply to soils?

19. Which would produce the earlier vegetables—other things being equal—a garden sloping downward toward the south or one sloping toward the north? Why?

20. Is the sun ever so warm that it injures the crops? What plants seem to like cool places? Which thrive best where it is warmest?

LESSON L

PLANT FOOD IN THE SOIL

Experiment 1.—Place a few drops of rain water or distilled water on a clean glass and cause it to evaporate by applying gentle heat. Repeat the experiment, using well water or "hard" water.

1. Account for the residue left in one case and not in the other.

2. Where does the well water get its mineral matter?

3. Why are lakes that have no outlet usually salt lakes? Does the experiment furnish proof for the reason?

GARDEN LOAM SUBSOIL

Experiment 2. — Take two similar plants and place the roots of one into a vessel of distilled water and those of the other into a vessel of hard water, and observe them for several days.

4. Do they grow and thrive equally well?

5. Which outlives the other? Why?

6. Explain how plants get their food from the soil, and the work done by the water in this process.

Note.—The carbonic acid gas and other gases in the air, when mixed with the soil, aid in making it soluble in water. This enables the water to take up mineral plant food from the soil, and we say such soil is fertile.

7. Why should the ground be thoroughly plowed?

8. Which is generally the more fertile, the soil or the sub-soil? Why? What is a common difference in their color? Which contains the greater quantity of plant roots?

9. What effect has the presence of organic matter in the soil upon its fertility? Which contains more organic matter, the soil or sub-soil? Why?

10. Does soil become exhausted, or worn out? Why?

11. How may new fertility be given it?

12. Should the same crop be planted year after year on the same ground? Why?

13. What advantage comes from a proper change, or rotation, of crops? Does nature rotate the crops of wild plants? Do the same kinds of weeds grow year after year in the same places?

Note.—The fertility of the soil is commonly maintained in three ways: First, by plowing into it barnyard manure; second, by rotating the crops and occasionally plowing under a fertilizing crop such as clover or cow peas; third, by using commercial fertilizers.

14. Under what circumstances would each of these ways be most economical?

15. Other things being equal, which lands will retain their fertility the longer, the irrigated farms of the arid regions or the cultivated lands of the humid regions? Why?

16. Have you noticed in plants any likes or dislikes for different kinds of soil?

17. What plants like heavy, damp soils? Which grow in dry, sandy places? Do any plants grow in alkali soils?

Note.—Plants grow in the margins of Great Salt Lake, whose leaves have a strong saline taste and when dried yield fine crystals of salt. It seems that no environment is so forbidding as to exclude plant life entirely.

Experiment 3.—Take some sub-soil and fill three small boxes. To one add a little fertilizer, and to another some humus, and plant beans or corn in all three. Keep them warm and moist and study the results in the light of the supply of plant food in each case.

SAND CLAY LOAM

Experiment 4.—Measure off four plats of ground in the school garden. Culitvate one thoroughly and another poorly, or not at all, but use no fertilizer on either. A third piece may receive barnyard manure and a fourth a commercial fertilizer and both of these be properly cultivated.

With these four kinds of preparations, plant all four plats with the same crop, as corn or wheat, and study the results, measuring the yield on each plat.

18. Which soils in your neighborhood seem to be most fertile? Which support most plant life? Can you tell good soil by its looks?

19. What soils do you know that are poor? Describe them. Why are they poor?

20. Why is the soil poor that has too much gravel? too much sand? too much clay?

Experiment 5.—Take cans of various kinds of soil, plant seeds in them and keep them warm and moist and test the relative amount of food for plants that each contains.

21. The first can in the illustration was filled with sand washed clean; the second with clay; the third with rich garden loam. All were planted at the same time with beans and kept moist in a warm window. The plants in the first can outstripped the others at first. Why? Why are they now the smallest?

22. Explain the present stage of growth in each case.

LESSON LI

PRINCIPLES OF PLANTING—SEEDS

1. When is the best time to plant most crops? Why? Which should be planted very early in the spring? Which may be planted later? Which may be planted latest and do well? Consider both garden and field crops.

2. Can any seeds be planted with profit in the fall? Name them.

3. Why cannot all seeds be planted in the fall? Which would die during the winter? Which would decay in the ground?

4. In planting a garden or field, what things must we take into account in deciding what crop to raise?

5. What do you think would be the most profitable crop to raise this year in a large field near your school? Why?

6. What would you plant in a garden near your house? Why?

7. What are most of the farmers planting in your vicinity this spring? What crops, if any, were planted last fall? Why are these crops preferred? Consider soil, moisture, market, seeds, labor, rotation of crops, etc.

8. After deciding what crop to raise, what care must be taken in buying the seed? Why should we buy the best seed?

Experiment 1.—Examine with a good lens, a variety of seeds. Note the many differences in shape, design, color, structure, etc., in them. Count the number of foreign seeds and withered seeds found in each sample and find the per cent of good, plump, sound seeds in each.

9. Why is it desirable that every seed planted shall grow?

10. Compare the probable results of planting poor and impure seeds with those of good and pure ones.

11. How may seeds be tested before planting them to see how many will probably grow?

Experiment 2.—Take 10, 20, 50, or any convenient number of seeds of a kind you wish to plant, and test their power to germinate by placing them in damp sawdust as described in the lesson on germination. If placed on a plate between pieces of blotting paper or canton flannel and kept warm and moist, for a few days, covering them with another plate to keep them dark, the fertile ones will germinate and can be counted.

12. If an average of 4 grains of wheat out of every 50 fail to grow, what will be the loss in one year on 1,000 acres of wheat land, needing 100 pounds of good seed to the acre, and yielding a crop of 30 bushels to the acre if every seed were to grow? Make other problems.

13. Name reasons why farmers do not like to plant too many seeds so as to insure planting enough good ones. What harm comes if too many seeds are planted?

14. Why are sugar beets "thinned" in the spring? What would be the result if they were not thinned? Why would it not be wise to plant the seeds so far apart as not to require this labor?

15. Can wheat be thinned in the same way if planted too thick?

LESSON LII

PRINCIPLES OF PLANTING—SPACE

1. What seeds may be planted close together? Why? Make a list of them.

2. What seeds should be planted farther apart? Why?

3. Make a list of plants that are tall and slim; another of plants that spread over much space. How will these habits of growth influence the distance at which the seeds should be planted?

4. Name seeds that are sown broadcast and close together. Why is this a good way of planting them?

5. What crops are planted in rows? Which of these have rows close together? Which are in rows far apart? Give reasons for each method of planting.

6. What seeds are planted in hills? Which of them are planted nearest together? Which are planted at the greatest distance? Why?

7. Why does planting in rows make cultivation easier? Why is it still easier to cultivate properly crops that are planted in hills?

8. Compare the sunlight received by plants in hills, in rows, and planted broadcast.

9. How do these three ways of planting affect irrigation?

10. In setting out trees, how should these same principles influence us?

11. Which trees require much space? which little space? Why?

12. In what ways do weeds injure crops?

Experiment.—Plant in the school garden seeds of the same kind at various distances and find out what distance is the best for each kind of seed.

LESSON LIII

PRINCIPLES OF PLANTING—DEPTH

1. What common seeds, when germinating, push their stems up through the ground with ease? Describe them.

2. How will this ability of the stem influence the depth at which the seeds may be planted?

3. What seeds have difficulty in getting their stems above the surface of the soil? Describe such stems. Recall the work done on germination.

4. Compare the stem of the squash seed and corn in this respect.

5. Name plants having slender, pointed, spear-shaped stems. What stems bear the two halves of the seed above the surface to form the first two leaves? How will these peculiarities influence the depth at which such seeds may be planted?

6. How may the size of the seed or the amount of plant food stored in it influence the depth at which it may be planted?

7. What happens if seeds are planted too deep? Why should some crops be planted as deep as possible without detriment?

8. Why is corn "hilled" up after it becomes quite large?

9. How deep should the following seeds be planted to secure the best results: cotton? corn? rice? beans? lawn grass? squash?

10. Consider other familiar seeds in this connection.

Experiment.—Plant the same seeds in the school garden at various depths. Record the depth of each and find out the proper depth at which to plant each sample tested.

LESSON LIV

CELLULAR STRUCTURE OF PLANTS

Experiment 1.—Remove carefully the rind of an orange. Separate the pulp into segments at the places where they join and remove carefully the membranous covering from one of the segments, showing the large, juice-filled cells and their arrangement.

1. How is the orange protected? Describe the rind—its color, thickness, odor, taste, and structure.

2. Into how many segments can you separate the pulp? Are there seeds in each segment? How many?

3. Describe the cells forming the pulp. Note how they are arranged and connected; their general shape; their contents; their walls or outer covering.

4. Is there any advantage in having the juice of an orange contained in so many cells, instead of being confined, like the milk of the cocoanut, within a single wall or vessel?

5. What other plants show a cellular structure to the naked eye? Examine the stems and leaves of water plants.

The pith of the elder and the pulp of the snowberry contain cells large enough to be seen.

Experiment 2.—Examine with a compound microscope the petals of a geranium; also a variety of petals and other transparent leaves. Cut with a sharp razor, thin slices of different parts of various plants, examine them, and discover how universal is the cellular structure in plants. If possible, procure a few properly prepared slides for the microscope to illustrate this feature.

6. Describe and draw the cells seen through the microscope. Note the variety of shapes and arrangement of the cells.

7. Plants grow by the addition of cells. Consider the wonderful law which causes the new cells, as they are formed, to assume certain shapes and positions to insure the peculiar form and growth of the respective plants to which they belong.

LESSON LV

CIRCULATION IN PLANTS

1. Examine the veins in leaves. In how many different ways do the veins in leaves run? Collect and study many samples.

2. Make a list of leaves having parallel veins; another with veins extending outward from a center midvein; another having veins extending outward from a point near where the leaf joins the petiole.

3. What is the office of the leaves of plants? Prove that they give off water.

Experiment.—Pluck a young, vigorous leaf from a geranium and place the stem in a bottle of water which has been colored with red ink or other convenient coloring matter. Set it in a sunny window for a short time. Note carefully what takes place. Cover the bottle with a tin can or put it in a dark place.

4. Account for the change of color that spreads over the leaf. Why does it begin where the stem and the leaf join?

5. Account for the shape of the colored spot as it increases in size.

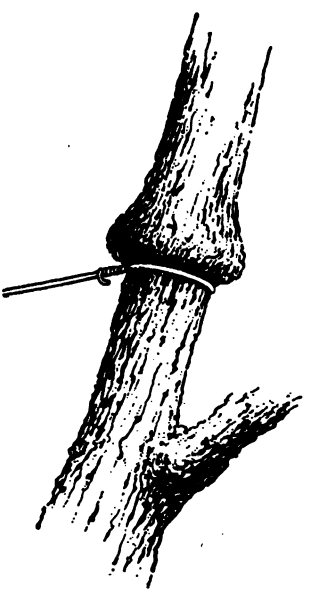
6. What service is no doubt performed by the water as it ascends and spreads throughout the foliage?

7. What effect has darkness upon the spread of the color? Infer the effect of night upon plant activity.

8. Account for the arrangement of leaves to get light.

9. What becomes of most of the water that reaches the leaves?

10. Account for the greater coolness of the shade of trees than that of other shades. (Recall effects of evaporation on temperature, Lesson 40, Fourth Grade).



11. Is there any evidence of a return movement of any of the sap from the leaves? How are other plant tissues made to grow?

12. Have you ever seen the twig of a tree enlarged immediately above a wire that has been twisted around it?

This may often be seen in young orchards where the nursery tags were attached by wires. The thicker sap will not pass downward as the thinner passes upward within the wire. This produces an enlargement. What thickens the sap?

13. Describe the sap of common trees. Within what tissues is it found? Make a willow whistle.

14. Describe the sap of the milkweed. Account for the plant's name. What is the appearance of the sap when dry?

15. Tell what you know of the sap of the maple tree. Describe the making of maple sugar.

16. Tell what you can of the sap of the India rubber tree and its manufacture.

LESSON LVI

HUMAN CIRCULATION

Experiment 1.—Feel with the fingers of the left hand the pulse in the wrist of the right arm. Find the pulse in the temple. A little practice will enable the pupils to discern the pulse.

1. Where else can the beating of the heart be felt?

2. Count the number of pulsations per minute.

3. Take vigorous exercise for a few minutes and count again.

4. Account for any difference observed in the rate or strength of the pulsations.

5. Does exercise affect the breathing in the same way? Account for it.

6. Why does vigorous exercise make us red in the face? Is it a healthful thing for us to do? Why?

Experiment 2.—Cross the legs by placing one knee immediately over the other.

7. Why cannot the uppermost foot be held still?

Note.—Each pulsation is caused by the action of the heart. The pure blood, coming from the lungs to the left side of the heart, and the impure blood from all parts of the body to the right side, causes the heart to expand. It then contracts with great strength, sending the impure blood to the lungs to be purified, and the pure blood to all parts of the body to build it up.

8. How does the pulse of an aged person compare with that of a youth?

Experiment 3.—Pinch between the thumb and forefinger a portion of the loose flesh on the back of the hand of a young person, and of an aged person. Account for the quickness of the one and the slowness of the other in resuming its natural position and color.

9. In which is circulation the more rapid and strong?

10. What effect has rubbing the skin upon the movement of the blood?

11. How does a hot bath affect the circulation?

12. Why should persons of sedentary habits take frequent exercise, bathe often, and rub the skin vigorously with a flesh towel?

LESSON LVII

HUMAN CIRCULATION (Continued)

Note.—After leaving the heart, the blood passes into a series of arteries, which divide again and again until they become a network of very fine capillaries in all the tissues of the body. Here the blood does its work. It builds up the worn-out tissues and dissolves out the used-up materials. The blood, now charged with various impurities, returns to the heart through a similar set of capillaries and larger veins, a dark blue, instead of a bright crimson liquid. The heart next pumps it though a large artery to the lungs, where the fresh air purifies it and it returns again to the heart to repeat its work.

To THE TEACHER.—A good diagram on the blackboard, or an anatomical chart may be used to much advantage in illustrating the circulation of the blood.

1. Can you feel any pulsation in the veins? Why not?

2. In which direction does the blood in the veins move? In what direction does it move in the arteries?

Experiment 1.—With the arm hanging loosely downward, shake the hand vigorously. Repeat with the arm raised above the head. What difference is there in the results?

3. Account for the difference in the size of the veins in the back of the hand after each experiment.

Experiment 2.—Grasp the left wrist tightly with the fingers of the right hand.

4. Why do the veins of the hand fill with blood?

5. If a string is tied tightly around the finger, on which side of the string will the finger swell and turn dark? Account for this.

6. How does tight clothing affect the movement of the blood?

7. When the veins are filled with blood, notice the knots in them, particularly near where they fork.

8. Against what danger is this provided?

Note.—Small pocket-like valves are placed here to prevent the backward flow of the blood.

9. Why are veins near the surface, while the arteries are buried deeper in the flesh?

10. In the case of an accidental cutting of an artery, where should a tight bandage be placed to stop the flow of blood?

11. If a vein were cut, where should the bandage be placed?

12. Is there any resemblance between the circulation of the blood in animals and the sap in plants?

13. In what respects is the work done by them alike?

LESSON LVIII

THE STUDY OF THE BLOOD

1. Do all animals have warm blood? Make a list of warm-blooded animals.

2. In what other espects do these animals resemble one another?

3. Make a list of cold blooded animals. Compare them in size and intelligence with the warm-blooded animals.

4. Do all animals have red blood? Mention some whose blood is not red. Is it warm or cold in these animals?

Experiment 1.—Examine, under the microscope, blood of various live animals as it circulates in the capillaries. This may be done in the following ways and will prove most interesting and instructive.

(a) Wrap a live frog in a wet cloth, allowing the hind foot to protrude. Spread his toes and hold them apart between two glass slips. Place the transparent web under the object lens and the blood may be seen moving rapidly through the tiny capillaries.

(b) A bat's wing placed in a similar position gives, perhaps, even a better view.

(c) The tail of a small tadpole is often used in a similar way. The tadpole must be kept wet or it will die.

(d) Place a small water newt in a watch glass of water, and as he lies still, the blood may be seen pulsating through the tiny vessels in the gills.

(e) In the semi-transparent legs of a small spider, confined between two glass slips, the moving blood corpuscles may be seen.

Experiment 2.—Examine a thin layer of blood on a glass under the microscope—a properly prepared slide will be better. Note the corpuscles or cells.

Experiment 3.—With the prick of a needle, draw a drop of blood from the finger and let it fall on a small, clean piece of glass. Examine it carefully with a lens or under the microscope.

5. Describe its appearance and any changes it may undergo.

6. Is it entirely liquid?

7. Does the entire drop clot?

8. Add carefully a few drops of water after it clots, and see if the clot will dissolve.

9. If allowed to dry, what will the clot form?

10. How are both man and animals often benefited by the clotting of blood?

Note.—The blood of animals clots more readily than that of man, and in some insects it hardens almost instantly, requiring no surgeon to sew up the wound.

11. What influence upon the circulation has breathing? Why should we always breathe plenty of pure air?

SEVENTH GRADE — FALL WORK

LESSON I

THE SUN'S HEAT

1. Define weather. Describe the various kinds of weather.

2. What is the difference between weather and climate?

3. What is the active agent in causing the various conditions that we call weather? (Review Lesson 5, Grade 5.)

4. Explain how the heat from the sun acts in causing different kinds of weather.

5. Upon what does it act?

6. What single cause influences most the changes in the temperature during the day? during the year?

Experiment 1.—Place in the sun two pieces of metal of the same size,—one with the edge toward the sun, the other with the side toward the sun. Which gets warm first?

7. What other influences, besides that of the slant of the sun's rays, affect the temperature of the air?

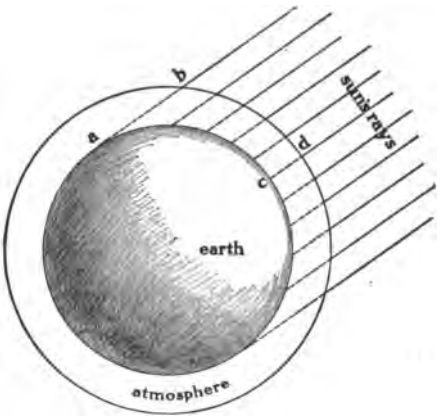
8. Is heat transmitted through any medium without loss?

Experiment 2.—Place one end of an iron poker in the fire, or one end of a copper wire in the flame of an alcohol lamp, and feel the temperature of the metal at various distances from the fire.

9. Will the distant end ever get as hot as the one in the flame? Why not?

10. How does distance affect the heat in passing through a medium?

11. Which ray of the sun, the direct or the slanting, passes through the thicker layer of air as it comes to the earth?



In the diagram, compare the distance that the ray *ab* travels through air with that of *cd*.

12. How will this condition influence the heat that comes from each kind of ray? Can you think of any other condition, besides the surface covered and the distance of air penetrated by a given ray, that will affect its heat?

13. What influences do clouds have upon the heat that we get from the sun? Why?

14. How does distance from the earth's surface affect the warmth? What experiences or observations of your own make you think so?

Note.—Scientists tell us that the heat contained in the direct rays of the sun is mostly insensible heat and cannot be felt until it strikes some surface and is reflected back and broken up. Then we perceive it. The air acts as a blanket in holding this reflected heat, and as the air is more dense near the earth than at great heights, it acts as a better blanket near the surface.

15. Give an example of the effect of altitude upon temperature.

16. Do all substances reflect heat equally well? Compare, in this respect, sand and clay; bare ground and lawn; different kinds of pavement, etc.

17. Which seems cooler, the shade of a tree or that of a house or porch? Why?

18. Which colors are warm? Which are cool? Why are dark colors worn in winter and white in summer?

19. Which substances absorb much heat? Which absorb little? When dark-colored leaves are blown by the wind upon the snow, why do they soon sink into the snow?

Experiment 3.—With a thermometer test different kinds of soil at various depths and under different conditions, and account for differences noticed in temperature.

20. Compare the temperature of soils that are loose; that are packed; that are covered with grass; that are bare; gravelly, sandy, clayey, wet, dry, etc.

21. How will the temperature of each influence crops planted in it?

LESSON II

THE NATURE OF HEAT

Experiment 1.—Place a cup of water on a hot stove and measure with a thermometer its gradual increase of temperature. A test tube of water heated in the flame of an alcohol lamp will serve as well.

1. At what point does the temperature cease to rise? Why?

2. What becomes of the additional heat received by the water after this temperature is reached?

3. Can this heat be felt? Is the steam that is formed hotter than the water?

4. Why is so much coal needed to "keep up steam" in a boiler after the water has reached the boiling point?

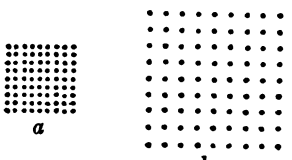
5. What happens to the steam if its heat is taken away?

6. If the temperature of water is greatly reduced, what change takes place in its form? In how many forms or states can water appear?

7. Mention other substances that may appear as solids, liquids, or gases, according to the amount of heat that they contain.

8. Explain the action of heat in changing the forms of such substances.

Note.—All substances are supposed to be made up of very small particles called molecules, as sandstone is made up of grains of sand. Heat is a form of energy which seems to separate these particles so that the substance occupies more and more space. (See cut.) Sufficient heat will cause the molecules to get so far apart that they cease to cling together, but move freely about, making the solid into a liquid. Still more heat drives them so far apart that they seem to want to get as far as possible from each other, and a gas is formed. The hotter the gas is made the greater will be its expansive force.



(*a*) COLD. (*b*) THE SAME HEATED

9. Recall the many ways of producing heat. (See Lessons 30–35, Grade 5.)

10. Considering heat as a form of energy, explain why it is developed by friction; by percussion; by chemical action; by combustion, etc.

11. Explain why it expands solids, liquids, gases.

12. Explain how ordinary temperatures are measured. Why is mercury used in thermometers? Why is alcohol used?

13. Are there temperatures that cannot be measured by the thermometer? What effect has great heat or cold upon mercury and upon alcohol?

14. How do workmen determine the temperature of a smelter furnace?

15. Find out how extremely cold temperatures are measured.

16. How is liquid air produced? What principles are used in making it?

17. How are the furnaces of smelters and of foundries made so extremely hot?

LESSON III

LAWS OF HEAT

1. Which side of an electric light bulb is the warmer?

2. What law of heat keeps us warm on any side of a camp fire? How may a wind or other conditions affect this law?

3. Give as many examples as you can of heat radiating in all directions.

4. Which takes the more fuel to heat a room, a stove or an old-fashioned fireplace? Why?

5. Describe a Franklin stove, and explain the philosophy of its construction. In what respects does it resemble a fireplace? Why is it more economical than a fireplace? Give an account of its invention.

6. For heating a large room, where should a stove be placed? Why?

7. Why do we get close to a stove or a radiator in very cold weather?

8. What effect upon temperature has distance from the fire or from the source of heat? Give illustrations.

9. Compare heat and light in this respect. Why do we

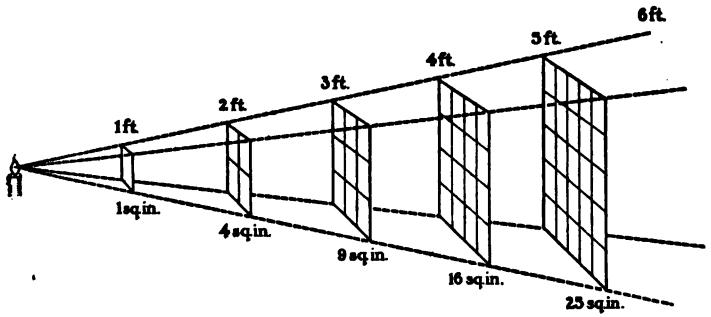
get close to the light when we are reading? What is the effect of distance from the lamp upon the amount of light received?

10. How does distance from a speaker affect our ability to hear him?

11. In what respects are heat, light, and sound alike?

12. In what proportionate degree does distance lessen the intensity of heat, light, and sound?

13. From this illustration deduce the law of the effect of distance, remembering that the amount of surface covered determines the intensity. (See Lesson 2, Grade 5.)



A square card placed one foot from a light will cast a shadow 2 ft. away, that will be four times as large as the card; 3 ft. away, nine times as large; 4 ft. away, sixteen times as large. How large will the shadow be 5 ft. away? 6 ft. away?

14. Prove that heat travels in straight lines.

15. Why does not the snow melt on the north side of the house as readily as on the south side? Give examples to prove that heat can be reflected.

16. Why will a screen cut off the heat when placed between a person and the fire?

LESSON IV

THE TRADE WINDS

1. Review previous work done on winds.

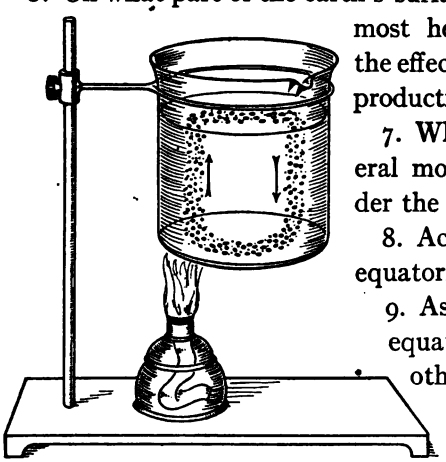
2. What is the chief cause of winds? Recall many experiments that show that heated air rises and causes currents in the atmosphere.

3. How do winds affect man's interests?

4. How do they affect climate?

5. Mention and describe the great regular winds found on the surface of the earth.

6. On what part of the earth's surface does the air get the most heat? Why? Discuss the effects of latitude upon the production of winds.



7. What must be the general movement of the air under the direct rays of the sun?

8. Account for the great equatorial calms.

9. As the heated air at the equator rises, where does other air come from to take its place?

10. What winds are thus established? In what directions will they move?

11. What becomes of this heated air at the equator after it rises? What general currents will be established there in the upper regions?

Experiment.—Heat one side of a beaker of water, in which float particles of wet sawdust, to show how currents are formed in water.

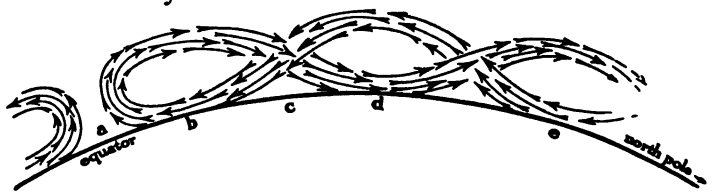
12. As the risen air flows away from above the equator in both directions and gradually gives off its heat, what will happen when it becomes colder than the air at the surface of the earth?

13. This will produce at the surface what kind of wind?

14. Following this wind at the surface until it again gets warmer than that which it meets from the poles, what will it be found to do?

15. Rising again, it continues its way to the polar regions, where it mingles with the air and finally begins to return to the equator. Will it remain at the surface all the way back? Why?

16. Make a diagram of a vertical section of the atmosphere between the equator and the north pole, illustrating the rising and the falling of the moving currents and the circuits that they make.



(*a*) Equatorial calm belt. The air is rising because it is so warm.
(*b*) Northern trade winds.
(*c*) Tropical calms, where air rises or falls.
(*d*) Stormy southwest winds, formed of the air which rose at the equator and became so cold and heavy that it fell on its way north.
(*e*) Arctic winds.

17. Make a similar diagram of the air movements in the southern hemisphere.

18. As the sun moves north and south over a belt 47° wide, how will this affect the regions of winds just described?

19. Will all these winds move directly north and south? What causes will modify these general directions?

Note.—It must be borne in mind that the earth, which is about 25,000 miles in circumference at the equator, revolves once in each 24 hours from west to east, and that the air tends to take upon itself the same forward movement at the part of the earth's surface upon which it rests.

20. A man standing on the equator will move through how many miles a day as compared with another standing at the pole? at a point 45° from the pole?

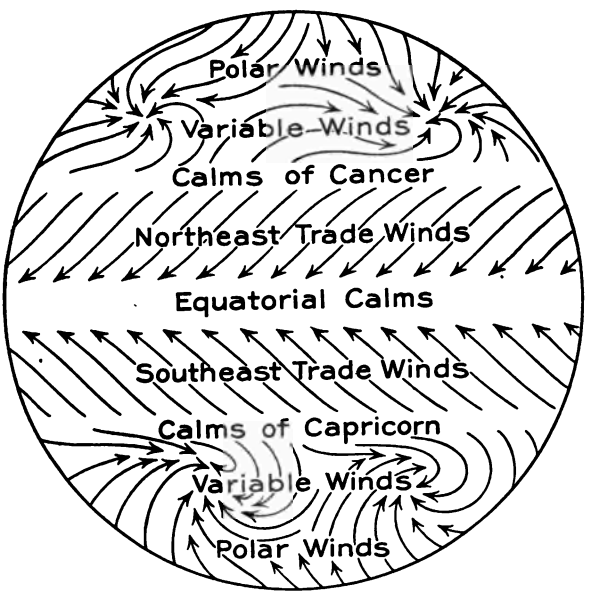


Diagram of the General Winds of the Earth

21. Illustrate this by revolving any globe on its axis, and explain the speed eastward at different latitudes.

22. In the diagram of the general winds, the sun is supposed to be directly above the equator. As it moves north or south $23\frac{1}{2}°$, how will these winds be affected?

23. Explain why air moving from the Temperate Zone into the Torrid Zone lags behind. How would this change the direction of such a wind? Apply to both hemispheres.

24. Why does the air coming from the north toward the equator seem to come from the northeast?

25. If air at the equator should move northward, it would be diverted to which side? Why?

26. Explain the Trade Winds as influenced by the foregoing principles.

27. Explain the tropical and the equatorial calms and their changes of position as the seasons change. How did they affect navigation before the steamboat was invented?

28. What destruction have you seen wrought by winds? The following table gives the velocity and the pressure of the wind.

29. From what direction do most of the cold winds called blizzards come? Why? In what states are blizzards most frequent and severe? Why?

30. What damage is often done by strong winds on the ocean? Give examples.

Description	Velocity in Miles per Hour	Pounds of Pressure per Sq. Ft.
1 Zephyr	2	.03
2 Gentle Breeze	7 or less	.23 or less
3 Fresh Breeze	11	.64
4 Strong Wind	18 or more	1.62 or more
5 High Wind	27	3.64
6 Gale	36	6.48
7 Strong Gale	45	10.
8 Violent Gale	58	17.
9 Hurricane	76	29.
10 Most Violent Hurricane	95	45.

LESSON V

THE SUN

1. Recall what you have learned about the sun and its apparent movements.

2. How does its light compare with that of other heavenly bodies? With artificial lights? Why do we not see stars in the daytime?

Note.—The sun's light is many times greater than that of the brightest electric light, other lights appearing absolutely black when held before the sun.

3. Does the sun give light to other planets besides the earth?

4. What come from the sun besides heat and light? Consider how the sun benefits plants and animals; how it aids the photographer; how it fades most colors; and infer by what means it does these things.

5. Can the sun's rays be made to produce motion?

6. What planets are nearer the sun than the earth? In what position would they be to cause their shady side to be toward us? How would this affect their brightness? Have you noticed any difference in their brightness?

7. Examine the sun through a piece of smoked glass; or, if possible, through a good telescope. Describe its appearance.

8. How large does the sun look to be? Compare its size with that of the moon.

Experiment.—Place a 12-inch globe on the desk to represent the sun, and a sweet pea to represent the earth. If these could be placed about 200 feet apart, we should have a fair representation of the sizes and the distance apart of the sun and the earth.

9. The sun is about 93,000,000 miles from the earth. What effect will this great distance have upon its apparent size? Give illustrations of this principle.

10. From the amount of heat this tiny earth gets from the sun at so great a distance, what do you think about the total heat given off by the sun?

Note.—One astronomer has estimated that in a single second the sun gives off as much heat as could be made from all the coal on the earth.

11. The moon is less than a quarter of a million miles away; how will this probably give us a wrong idea of its size as compared with that of the sun?

12. The earth is about 8,000 miles in diameter, and the sun about 870,000 miles. How many earths the size of ours would it take to make a body as large as the sun? How many sweet peas would the 12-inch globe hold?

13. Find out from books in the library or from other sources all you can about the sun and report to the class.

To THE TEACHER.—At a time when the interest of the pupils is awakened through their own observations and study, they should be told something about the history of the science of astronomy; the theories and myths of the ancients; the invention of the telescope, and the changes it made in astronomy. The simpler laws of the heavenly bodies also should be explained.

LESSON VI

PRINCIPLES OF PRECIPITATION

1. When a mist rests upon the surface of a lake or upon damp ground, what do you conclude as to the temperature of the lower layers of air compared with that of the higher ones? Heat would have what effect upon the mists?

2. Why does cooling the air make visible the vapor in it? If cooled still more, what would happen to the vapor?

3. What is the chief principle that determines the amount of vapor the air will contain?

4. Explain why a cold wall or a pitcher of ice-water sometimes "sweats."

5. Explain why dew forms on grass and other plants rather than on rocks and boards.

6. Why do most flowers close at night? Why does dew form mostly at night?

7. When the temperature is below freezing point, what will form instead of dew? Is frost frozen dew?

8. Tell how hoar frost is formed: if possible, observe it forming. This may sometimes be done during a fog. Compare the hoar frost with the first crystals that form when water is turning into ice.

9. How does vegetation add to the moisture of the air?

Note.—A large tree evaporates from 100 to 200 gallons of water each day; and it is said that each pound of wheat has used a barrel of water. Recall experiments tending to prove this.

10. Does vegetation influence rainfall in any degree?

11. Make a special study of conditions that accompany a thunderstorm, and report to the class.

12. Why does the air feel sultry before a thunderstorm? Do you think it is dry or moist? Why?

13. At what time of day do such storms usually occur? Why?

14. When a layer of air near the surface becomes very warm, can it rise as a great layer or sheet? What would prevent it?

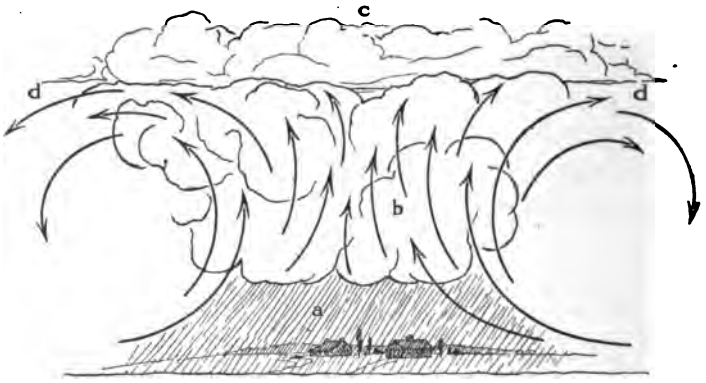
15. How can it get past the cold layers that press down upon it?

Note.—On a calm day in summer the air near the earth often becomes warm and full of vapor. Though lighter, it cannot get above the colder layers until the equilibrium is disturbed by something and an upward flow is started. All the warm air seeks to escape upward through this invisible chimney.

16. What happens to this air when it mixes with the cold air in the upper regions?

17. Account for the lightning that always comes with a thunderstorm.

18. Why does a thunderstorm often follow a battle?



A THUNDERSTORM

The lowest layer of air becomes very warm and moist, and feels sultry. When the equilibrium is disturbed, an uprush begins. Rain clouds (b) are formed and rain (a) is soon developed. The thermometer falls. The arrows show the direction of the air currents. The storm moves generally from west to east. Its approach is often indicated by a sudden rise in the barometer followed by a fall.

19. Why does the exploding of dynamite in the upper regions sometimes cause a thunderstorm? What conditions are necessary to make rain in this way?

20. Under what conditions might the precipitation be snow instead of rain? Could these conditions be analogous to those when hoar frost instead of dew is produced?

21. What effect has a shower of rain upon the temperature of the air? Why?

22. Why is the air often made warmer by a snowstorm?

Experiment.—Melt some fragments of ice in a beaker of water over a flame. Keep a thermometer in it and note any changes in temperature.

23. When does the temperature within the beaker begin to rise? What became of the heat received previously? Compare with Experiment 1, Lesson 2.

Note.—Heat consumed in melting ice or in vaporizing water becomes *latent* or *insensible* heat. When vapor condenses or water freezes, this latent heat is liberated and again becomes *sensible* heat.

24. When the vapors in the air are condensed into ice crystals, as in a snowstorm, what must be true as to the amount of heat liberated?

LESSON VII

FARM WORK IN THE FALL

A Field Lesson.—Every pupil should spend, if possible, a few weeks on a farm and become familiar with conditions and activities there in both spring and fall. At least a day may be spent at some near-by farm.

1. Name and describe the different buildings seen on a farm, and tell how each is adapted for the use that is made of it.

2. What useful animals are found on the farm? Study the following points concerning each of them: number,

GATHERING APPLES

DIGGING POTATOES

REAPING WHEAT

THRESHING WHEAT

value, breed, size, rate of increase, food, shelter, use, and care.

3. What crops are on the farm? Consider the number of acres of each kind, when and how planted, care given, yield per acre, value, time and method of harvesting, etc.

4. What tools and machinery are used in the fall? Describe the construction and use of the wagon, the mower, the rake, the hayrack, hayfork, potato digger, threshing machine, and any other machines or tools used on the farm.

5. How is each crop cared for during the winter? Describe a haystack, potato pit, corncrib, granary, fruit cellar, silo, etc.

6. What care is taken of the machinery during the winter?

7. How are the different animals sheltered and cared for? What food is given each kind?

8. How are the different crops harvested and prepared for market? Describe: (*a*) the digging of potatoes and puting them into a pit; (*b*) the cutting, shocking, husking, and shelling of corn; (*c*) the cutting, binding, stacking, and threshing of wheat and small grain; (*d*) the cutting, raking, piling, and stacking of hay; (*e*) the picking, ginning, and baling of cotton; (*f*) the gathering and packing of apples, and the handling of any other crops that you may have seen harvested.

9. What prices does the farmer get for his different crops?

10. Describe how various crops are packed and taken to market.

11. What work has the farmer to do in the winter?

12. Estimate the expenses of some near-by farmer and the value of his crops.

LESSON VIII

DISSEMINATION OF SEEDS

Field Work.— Visit fields, woodlands, hillsides, streams, and marshes, and study the work of plants of all kinds in maturing their seeds and in getting them scattered. Collect samples of seeds to study in the class.

1. Make drawings of typical plants and seeds as the work progresses.

2. Group seeds having similar habits and structure. They may be mounted on cardboard forming charts, or placed in separate boxes and labeled.

3. Of what use in nature are weeds and wild plants? Was the divine decree placing "thorns and thistles" in the earth wholly a curse?

4. Have they aided or hindered man more in "eating his bread by the sweat of his brow"?

5. Consider the vast work of wild plants in mixing with the soil and in rendering it fertile; in breaking up rocks into soil; their influence upon precipitation and the moving of soil; their work in removing carbonic acid from the air; the support that they give to animal life, and the many other ways in which they benefit man.

6. Under what circumstances are they harmful?

7. How are the multitudes of plants found in all sorts of places and conditions provided with means of survival?

8. In how many different ways are their seeds scattered? Recall the work done in the Third Grade on seed distribution.

9. Why is it necessary that the seeds should be scattered? Consider the need of young plants for soil, light, moisture, and room to grow and mature.

10. Mention all the means you can that plants employ to get their seeds scattered. Make a list of these means in the order of their importance.

11. Mention all the seeds you know that are moved by the wind. Make a list of them and collect samples of as many as

MILKWEED SEEDS

you can find, keeping them in a box by themselves for study in the class.

12. Study separately each seed that the wind scatters, and the plant that bears it, considering the following points:

(*a*) the height of the plant and the height of its neighbors;

(*b*) the position of the seed on the plant;

(*c*) the size and the weight of the seed;

(*d*) the pappus, wings, sails, or other appendages to catch the wind;

(*e*) the number of seeds produced;

(*f*) the chances that the wind will take them to a suitable lodging place to grow.

13. Find plants that you think grew from seeds that were deposited by the wind.

14. How far have you known wind to carry seeds? Look in nooks and corners, in dry ditches and holes, for seeds that the wind has deposited. Consider their chances to grow.

15. In a similar manner collect, list, and study all the seeds you can find that may be carried by water. Consider the following points:

(*a*) Do they float on water? Test them.

(*b*) Do they float at first and sink when water-soaked?

(*c*) Does the plant bearing them grow near the water?

(*d*) Where and how will the water deposit the seed?

(*e*) Will the wind aid the water in this work?

(*f*) Which may adhere to the feathers of water fowls and be carried by them to distant parts?

(*g*) Find plants that evidently grew from seeds carried by water.

16. Study also seeds scattered by animals. Consider the following points:

(*a*) Was the seed used by the animal for food?

(*b*) Was it surrounded by a fruit covering?

(*c*) Has it hooks or burs for clinging to the animal's covering?

(*d*) Was the plant edible on which it grew?

(*e*) What attracted the animal to approach the plant?

(*f*) Where and how the animal will drop the seed.

17. What plants help to distribute their own seeds? Describe various adaptations of plants to aid this work.

18. What seeds has man distributed accidentally? Consider:

(*a*) seeds that have clung to his clothing;

(*b*) seeds that have clung to wool, hides, and animal coverings, which man handles and ships to different places;

(*c*) seeds mixed with grains and with other merchandise;

(*d*) where such seeds find places to grow;

(*e*) the effects of such growth.

19. What seeds and plants does man distribute purposely? Consider:

(*a*) seeds of useful plants, grains, fruits, etc.;

(*b*) the work of the Agricultural Department in this respect.

20. What crops grown in the United States come from seeds obtained in foreign countries?

21. What important crops grown in foreign countries originally came from America?

LESSON IX

BARRIERS TO PLANT DISTRIBUTIONS

1. When there are so many seeds developed by wild plants and so many ways to distribute them, what conditions hold the plants in check, and fix their bounds?

2. Imagine the condition of the world if all the seeds that are produced should grow.

3. Make a list of all the barriers to plant distribution that you can think of. Which is the most important one?

4. How does temperature fix limits to plant growth? Give many examples. (Recall work in Lesson 9, Grade 6.)

5. What plants are started in greenhouses and in hotbeds? Why?

6. How does moisture affect the distribution of plants? Name as many desert plants as you can. Which grow in

marshes? Which require only a moderate amount of water? How do these conditions fix their dwelling places?

7. How do oceans act as barriers to seed distribution?

8. Would a large river be a barrier over which wild seeds could not cross? Do you know of any plants that are common on one side of a river and not found on the other?

SCENE IN THE MOUNTAINS OF THE NORTHWESTERN PART OF THE STATE OF WASHINGTON

9. How may a mountain chain prevent the onward march of plants? Compare the plants on the two sides of any mountains with which you are acquainted.

10. How does altitude check plant life? What plants are abundant at the base of any mountain you have seen that are not found on its sides or summit?

Note.—A most striking illustration of the influence of altitude (and consequent temperature) is found on a large scale in eastern Mexico, where the surface falls in three broad terraces from the plateau to the coast. Near the City of Mexico the apple, pear, and other fruits of the Temperate Zone thrive; going eastward, a sudden descent brings the traveler to the Tierra Templada, or temperate country, where semi-tropical plants are found; on the coast plains near Vera Cruz the banana, pineapple, and other tropical plants abound.

11. Make a list of plants as they might occur on the fertile sides of a very high mountain in the Tropics.

12. How may the nature of the soil influence plant growth? Which plants grow only in sand? Which like heavy clay soils? Which thrive best in loam?

13. Will alkali in the soil produce a similar effect? Which plants can endure most alkali or salt?

Note.—The waters of Great Salt Lake contain over 20 per cent of salt and will sustain neither animal nor plant life. Near its margins, however, where a little fresh water mingles with it, a succulent plant grows whose leaves have a strong saline taste and are, when dry, covered with salt crystals formed by the evaporation of the salt water in their tissues. Still farther, where more fresh water mixes with the brine, other plants grow, containing less salt. More remote still, the common salt grass is abundant, and beyond this most of the common wild and cultivated plants will grow.

14. How do birds limit the spread of plants? Find out the amount and the kinds of seeds that some birds destroy.

15. Make a list of seeds that you have seen birds eat, and name the birds that you have seen eating them. Your Natural History Calendar should contain much of this kind of information.

16. Make a list of the plants that annoy and injure man and tell why they are undesirable in gardens and in fields.

17. Tell how different ones may be destroyed and prevented from growing where they will do harm.

LESSON X

THE ENGLISH SPARROW

Experiment.—Provide or find a nest of an English sparrow where it will be easy to watch it during a season. Make regular observations and find out all you can of its habits, food, etc., and record what you learn. This bird is so tame that observation will not be difficult.

1. Describe the English sparrow. How does the male differ from the female? How does it differ from other members of the sparrow family?

2. How many kinds of sparrows can you recognize?

3. Do English sparrows go in flocks, in pairs, or singly? Do they sing? What noises do they make?

4. Describe their movement on foot and when on the wing.

5. What do they eat? How do they eat? Where do they get most of their food? Is their food-getting a benefit or a detriment to man? Consider both those that live in the country and those found in the city.

6. Describe their nests. Where are they generally built? Why are there often found so many soft feathers in nests so coarse and unshapely?

Note.—The male bird often brings feathers to cover the eggs and keep them warm.

7. What are their nesting habits? When do they begin nesting? How long does it take their eggs to hatch? How many broods will a pair raise in one season? How many young are there generally in a brood?

8. What are the chief enemies of the English sparrow?

9. Describe the disposition of English sparrows.

10. Their proper name is "house sparrow"; infer its

origin. Why are they called English sparrows? Give an account of their introduction into America.

11. How do they treat other birds? How do they escape other birds?

12. What good does the English sparrow do? What evil is he guilty of doing?

13. Should this bird be encouraged or destroyed? Why?

LESSON XI

BALANCE OF POWER AMONG ANIMALS

1. If each pair of English sparrows hatches five settings of eggs, of eight nestlings each, in a season, how many sparrows will come from each pair in two years? in three years? in five years?

Note.—If all the progeny of a pair of English sparrows should live for ten years, it has been estimated that they would amount to over 175,000,000,000—a number too great for us to comprehend.

2. How would such an increase affect conditions in the world?

3. Are the sparrow's eggs ever destroyed? Consider hawks and other birds, cats, insects, the weather, food supply, and man, as possible destroyers of the English sparrow.

4. A toad or frog will produce as many as 10,000 eggs in a summer. What prevents a continual "plague of frogs"?

5. Estimate the natural increase of the house fly. What are its natural enemies? Is it of any use to man? What conditions favor its increase? What conditions prevent its increase? When is it most needed? When is it dangerous?

6. In many places rabbits become so numerous as to destroy crops. What natural enemies of rabbits should then be encouraged? Consider eagles, hawks, coyotes, etc.

7. About how many eggs does a common grasshopper or locust lay in a season? What enemies hold them in check? How does man destroy them when they become too numerous?

Note.—The first crops planted by the Utah pioneers were attacked by hordes of black crickets, and were about to be destroyed. This would have meant starvation to the people whose frantic efforts to kill them were futile. A great flock of seagulls, whose home for generations had been on the islands of the Great Salt Lake near by, came to the rescue just in time to save the crops by devouring the crickets with astonishing appetites—a most Providential deliverance. The seagull is now protected by law and held in grateful remembrance. Salt Lake City is about to erect a costly monument in honor of this bird and to commemorate this incident.

8. In several towns in northern Arizona hordes of bats have taken possession of schoolhouse attics, haylofts, and such places. Since their arrival no mosquitoes are found there in the ponds and marshes near by. Infer a connection between these two facts. Why are the apples in these towns free from worms now? Why do the house flies there flourish undisturbed as heretofore?

9. The bats in northern Arizona have become a nuisance. How may they be repressed by natural means? by artificial means? What effect would their destruction probably have upon the mosquitoes, etc.?

10. Mention other animals or insects that at times become so numerous as to be a menace. Make a list of all such animals that you can think of, and opposite each kind mention its natural enemies.

11. Find out how the orange groves of California were saved by the ladybug from being destroyed by the San José scale, a very small animal.

12. Do you know of any animal that has been driven out of your neighborhood by its natural enemies? by man?

13. How do diminished numbers contribute to the safety of any species from its natural enemies?

14. Do you know of any species that has become extinct? Infer reasons.

15. In what respects is this balance of power among animals a wise provision? Does it ever work results that are to be regretted?

LESSON XII

ANIMAL PARASITES

1. What small animals live upon larger ones?

2. Do you know of any that live within the bodies of other animals? Make a list of each kind.

3. Which pass the whole of their lives on the host animal?

4. Which of these often trouble man?

5. Which are found on dogs? on horses? on sheep? on cattle? on chickens?

6. Tell what you know or can find out about the life habits of the following animals: mite, louse, flee, woodtick, botfly, trichina, tapeworm, etc.

7. What causes "scab" in sheep? How are "scabby" sheep treated and why?

8. What treatment should poultry receive for chicken lice?

9. What precautions should be taken against trichina?

A SMUDGE

In the smoke of a smudge, or a smoldering partially green log, which will burn for days, the horses in Arizona find a refuge from the fly pest in summer.

Note.—Some parasites are made to serve a useful purpose. Where a scourge of grasshoppers exists, the Agricultural Department will furnish a quantity of live grasshoppers which are afflicted with a minute parasite. When these grasshoppers are turned loose among the others, the parasites, which increase with incredible rapidity, soon spread to all of them and thus destroy the scourge.

TO THE TEACHER.—Assign to each pupil a parasite to study and report upon to the class. Whenever possible, the pupils should study specimens; but they may also get information from the library or from other sources.

LESSON XIII

PLANT PARASITES

Experiment 1.—Raise in the school garden, or procure elsewhere, samples of dodder. Cut the stem near the ground after the plant has begun to climb up another plant, and note the effect. Bring to the class samples of dodder with the plants to which they cling.

1. How does the mature dodder plant get its nourishment?

2. What effect has it upon the host plant?

3. Why is it troublesome to farmers? How do they get rid of it?

a *b*

EFFECTS OF THE MISTLETOE

a. Showing how it robs the twig of its due nourishment; *b*, showing how it will kill its host, even though the latter be a large tree.

4. A plant that draws its nourishment from another plant is called a parasite. Mention all the plant parasites that you know.

5. Describe the mistletoe. For what is it chiefly noted? How are its seeds scattered? What effect has the mistletoe when abundant in a grove?

6. Examine with a microscope mold, mildew, smut, rust, potato blight, ergot, etc., and describe each. In what respects do any of them resemble plants?

7. What are their effects upon the plants bearing them?

8. Which of these are found also on dead trees, fruits, pieces of old bread or cheese, old bits of leather, etc.?

9. How does mold come to grow on these things?

Experiment 2.—Seal within a glass fruit jar a piece of moist bread, heating it as in canning fruit. Observe it for several days—no mold appears. Run a piece of clean wire—a hat pin will do—into some yellow or brown mold that may be on some near-by object, draw it across the piece of moist bread, and await results for a day or two.

10. How does the mold that now forms on the bread compare with that through which you ran the wire? Infer how it came to grow on the bread.

11. Give instances where parasites have done great injury.

Note.—A few years ago the beautiful forest surrounding the Castle of Chapultepec near the City of Mexico, the official home of the President of Mexico, was threatened with destruction from a long gray moss that covered the limbs and twigs of the great cypress trees. Many men were employed by the government for several months removing the moss, after which the trees resumed their former healthy appearance.

12. Do you know of any plant parasites that are useful?

13. Suggest means of getting rid of those that are undesirable.

Note.—Must and blight and various kinds of the smaller forms of parasite plants may be destroyed by spraying the host plants with the Bordeaux mixture. This is made by dissolving one pound of blue

vitriol (copper sulphate) in about twelve gallons of water. A pound of fresh quicklime also is dissolved in another vessel containing about five gallons of water. The two solutions are then mixed and strained. The mixture is put on to the best advantage with a spraying pump.

LESSON XIV

HOW PLANTS SECURE LIGHT

A FIELD LESSON. — Visit various places where plants of different shapes and sizes may be seen growing, and study them with special reference as to how they get the light that they need. Get samples of plants grown in abundant sunlight, and others of the same species grown in the shade. Notice also plants that have grown in a dark cellar, under a board, or in the dense shade of larger plants or a forest.

1. In how many ways do plants contrive to get their leaves into the sunshine? Consider the following points and illustrate each with an example, if possible:

(*a*) the stem or trunk and its direction, length, size, etc.;
(*b*) the number, size, and arrangement of the branches;
(*c*) the position, size, and shape of the leaves;
(*d*) the length of the petiole and movement of the leaves;
(*e*) the aid secured from neighbors;
(*f*) special effort or shape assumed to meet some special condition.

Experiment 1. — Cover with a tin can a vigorous plant, keeping it warm and moist for a few days, and note the results of darkness.

2. Have you seen stems or branches change their form or bend to get the light?

3. Do leaves keep the same side toward the sun all day? Which side is generally upward?

4. Infer a reason for giving the sunflower its name.

Experiment 2.—Cut away or pull up overshadowing weeds from above plants that are suffering from the lack of sunlight and note the change.

5. Tell how and why a garden should be kept weeded. Is it equally necessary to keep large fields and orchards free from weeds?

Experiment 3.—Cover part of a large leaf in the morning so as to keep off all the light, allowing the sun to shine upon the rest of the leaf. Two pieces of cardboard on opposite sides of the leaf held in place by letter clips may answer. Remove them in the evening and note the difference in the two parts of the leaf.

Experiment 4.—The sunshine produces chemical changes in the leaf necessary for the growth of the plant. If you now immerse the leaf over night in chloral hydrate to remove the green color, and then place it in a solution of iodine, you will find that the part of the leaf that was shaded will not show the starch reaction, while the other part will. This proves that the sun helps the plant to make starch.

6. Suggest a reason for the better development of the topmost fruits and leaves. Compare them with those that grow on the lowest boughs.

7. How may this knowledge influence us in planting? How should it influence the pruning of an orchard?

LESSON XV

ANNUAL, BIENNIAL, AND PERENNIAL PLANTS

1. What plants have already matured their seeds this season and died? Which of these live only one year? Collect samples to study.

2. Make a list of all the plants you know that live but one year. Which are wild? Which are cultivated? Plants that live only one year are called *annuals*.

3. What is the general effect upon a plant of bearing seeds?

Experiment.— Carefully remove the blossoms from a plant and see if it grows more or lives longer than other plants of the same kind that mature their seeds. Other conditions should be equal. Also compare twigs on a fruit tree that bear with those that do not, and account for any differences you may observe.

4. Which plants mature their seeds early? Which plants mature them late? Why is this a wise provision in nature? What would be the effect if all the seeds ripened at the same time?

5. Which annual plants would live longer were they not killed by the frost?

6. What plants live two years and then die? Make a list of them. Such plants are called *biennials*.

7. When do most of these plants bear their seeds?

THE BULBOUS PLANT NARCISSUS

8. What preparation do they make for this work during the first year? Which store food in their roots? in their stem?

9. How does man take advantage of these preparations? Make a special study of the life history of the beet, carrot, cabbage, etc., learning how and when each is planted, cultivated, harvested, marketed, and consumed, and how and when it bears its seeds.

10. Why are the earliest flowers mostly bulb plants? Are such plants usually annuals or biennials?

11. As the seeds grow the second year, what takes place in the size of the root or in the store of food?

12. Compare the seeds of annuals and biennials as to the quantity produced by plants of similar size.

13. What plants live for many years? Such plants are called *perennials*. Make a list of them.

14. Which of the three kinds include the greatest number of different varieties? Consult your lists.

GIANT CACTUS, ARIZONA

15. When do perennials begin to bear seeds? Compare the preparations that they make for doing this work with those made by the annuals and the biennials.

16. What perennials die after bearing seeds once? Which continue bearing for many years? Do all fruit trees bear every year? Infer a reason.

17. Make a special study of one or two common perennials that grow near the school.

18. What plants have roots that live many years while their tops die down each fall? When do they bear their seeds? What labor and danger do they escape?

19. Which of these plants are useful to man? Make a special study of alfalfa.

20. Which of the cultivated plants mentioned in the class could survive in this climate without man's aid? Which could not? Give reasons for your answers.

SEVENTH GRADE—WINTER WORK

LESSON XVI

TEETH AND CLAWS

1. Examine as far as possible the teeth and mouth parts and the feet and claws of the following animals, and be able to describe and draw them:

(*a*) the dog, as type of the fox, wolf, coyote, etc.;

(*b*) the cat, as type of the wildcat, panther, tiger, lion, etc.;

(*c*) the bear, as type of the raccoon, mink, weasel, etc.;

(*d*) the cow, as type of the sheep, goat, deer, bison, etc.;

(*e*) the squirrel, as type of the mouse, rabbit, beaver, etc.

2. For what kinds of food are the teeth of the dog adapted?

3. Wherein do they differ from those of the cat family?

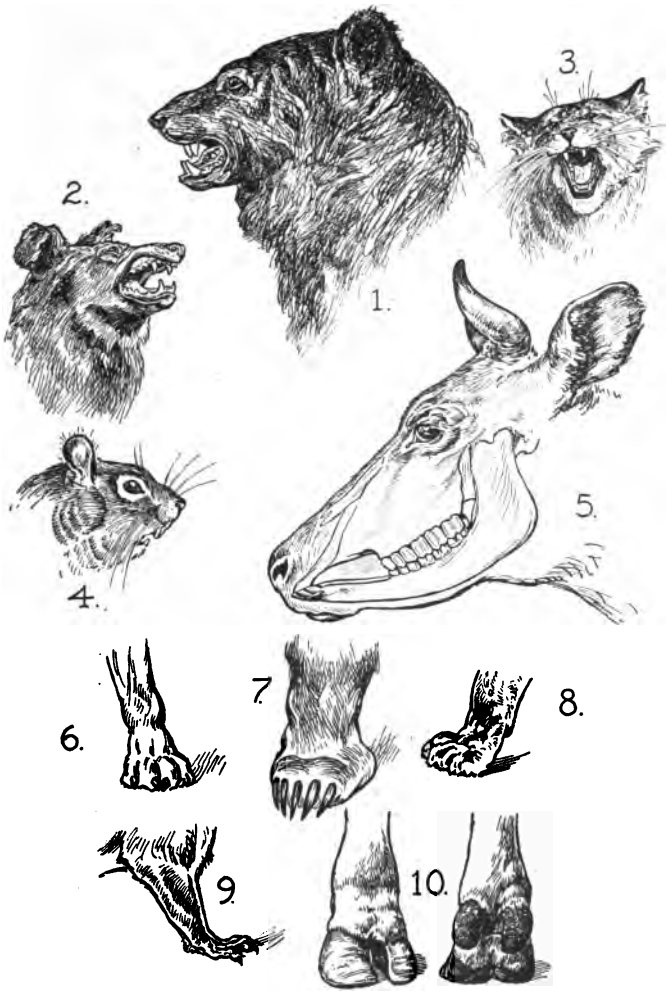
4. Which class has both teeth and claws best fitted for tearing the flesh from the bones of its prey?

5. Which class has a rough tongue? Infer its use in food getting.

6. Which class is best adapted for digging in the ground? for climbing trees? What habits make these powers needful?

7. Will a cat eat stale flesh? What is the condition of much of the flesh eaten by the wolf?

8. Why does the dog family need a very keen sense of smell? Why does a dog often bury a bone? Is this ever done by a cat?



Head and foot of a bear (1 and 7), of a dog (2 and 6), of a cat (3 and 8), of a squirrel (4 and 9), and of a cow (5 and 10).

9. Why do wolves need to go in packs? Why do not tigers? Find one reason in the structure of their teeth and claws.

10. What foods are eaten by the bear family? How are their teeth adapted for those foods?

11. Consider their feet and claws as fitted for their habits of life.

12. Why are the teeth of the cow and the horse broad and flat? What foods do they eat? How would the tiger's teeth serve the needs of the horse?

13. Compare the front and the back teeth and account for their differences.

14. Why has the horse front teeth on both jaws, while the cow has them on only one? Describe how each eats grass.

15. Why do the teeth of many herbivorous animals have enamel distributed through them?

16. Why is a split hoof better for a cow, and a single hoof for a horse? Which is better adapted to graze on low, marshy lands? on dry or stony ground? Why?

17. Why are animals of the squirrel type called *gnawers?* For what special purpose are their front teeth adapted?

18. What harm do gnawers often do to man?

19. Why do their front teeth grow as fast as they are worn away? How are they kept sharp and chisel-shaped? Compare the thickness of the enamel on the front and rear sides of these teeth.

20. Tell what you know of the uses made of these teeth.

21. Which of the gnawers have feet adapted to burrowing in the ground? to climbing in trees?

22. Upon what kinds of food do the different species live?

23. What are the enemies of each? Describe their methods of defense or escape.

TO THE TEACHER.—A different animal may be assigned to each pupil to study and report upon to the class. The pupils may get information by observation, by inquiry from persons acquainted with the animals, and by reading books and magazines about them; they may illustrate their report with pictures, with mounted specimens, or with the live animal when possible.

LESSON XVII

THE HUMAN TEETH

1. Why do we have two sets of teeth? Do lower animals have two sets?

2. How many teeth do we have in our first set or *milk* teeth? How many in our second set or *permanent* teeth?

3. At what age do we "cut" the different teeth in each set? Do they meet needs that develop as the teeth appear?

4. How many front teeth have we? What is their chief use? How are they adapted for this use? They are called *incisors*.

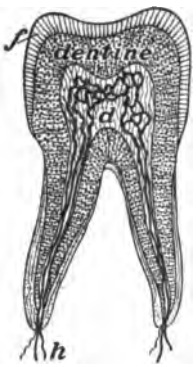
5. How many *canine* or *eyeteeth* have we? What is their chief use? What animal's teeth do they resemble? What do they suggest regarding the nature of man's food?

6. How many grinding teeth or *molars* are there in an adult's set of teeth? Are they all of the same size? The two smaller ones on each jaw are called *premolars*.

7. What work is done by these teeth? Are the molars adapted for masticating animal or vegetable foods?

8. Judging from our teeth, about what proportion of our food should be meat?

Experiment.—Get a tooth and break it open with a hammer and examine its structure. Test the hardness of the enamel and the ivory or dentine, and note the cavity within.



SECTION OF A HUMAN TOOTH

f, the enamel; *d*, the pulp; *h*, entrance of nerves and blood-vessels.

9. Which teeth have only one root? Which have two? Which have three? Infer a reason for this difference.

10. Which part of a tooth is covered with enamel? Why? It is called the *crown*.

11. Where are the nerves and the blood vessels that nourish the teeth?

12. What makes our teeth decay? Do the teeth of animals decay as easily?

13. Explain how and why we should use a toothpick; a toothbrush.

14. Where do cavities in the teeth most frequently form? Why?

15. How does a dentist arrest decay when a cavity is formed? What will be the result if such a tooth gets no attention?

16. What foods and drinks injure our teeth? Consider such as are hot, cold, sweet, sour, etc. How may cracking nuts with the teeth injure them?

17. What causes toothache?

18. Why are good teeth necessary to good health?

19. What care should be taken of the teeth?

20. Why should we chew our food a long time before swallowing it?

21. How does the condition of our teeth affect the time we should take in eating?

LESSON XVIII

CAPILLARITY

1. In nature does water always run downward? How does a sponge get wet when laid in a shallow vessel of water?

Experiment 1.—Dip the end of a small glass tube into water and compare the height of the surface inside and outside the tube. Try tubes of different sizes.

2. What effect has the tube upon the height of the water?

3. How does the size of the tube influence the height of the water?

Experiment 2.—Place vertically in a vessel of water two panes of glass, holding the edges on one side in contact with each other, but slightly separated on the other side. Notice how the water rises between them.

4. Where does the water rise the higher? Account for the difference in height from one side to the other.

5. Upon what does the height of the water seem to depend?

Note.—This power of tubes and crevices to attract liquids is called *capillary attraction* or *capillarity*.

6. Mention many common examples of the use of this principle. Consider the use of blotting paper, towels, lamp-wicks, absorbent cotton, and as many other things as you can think of that possess capillarity.

7. How do plants use this natural power? Consider what liquids move in roots, stems, and leaves.

8. Consider the power to lift the sap of plants to the tops of the highest trees.

9. How does the life of animals also depend upon capillarity? Does the heart do all the work in moving the blood? Give a reason for your answer.

10. In irrigating land the water sinks into the soil through tiny capillaries and crevices. Why does running a drag or a cultivator over the ground, as soon as it is dry enough, prevent the water from returning through the same openings?

11. Why does "mulching" the ground retain its moisture?

12. What things are valuable because they will absorb liquids?

13. What things are useful because they are impervious to water?

14. Think of as many uses of capillarity as you can in nature and in the arts.

LESSON XIX

GRAVITATION

1. What makes everything seem to want to fall to the ground? Can you think of anything that has not this tendency?

2. Are things that rise,—balloons, for example,—heavier or lighter than air? If there were no air, do you think that they would still tend to rise? Do they ever rise above the air? Why?

3. Why does wood float on water? If the water under it were removed, would it still float?

4. What do we call the act of measuring the force that pulls things toward the earth?

5. Do all substances have weight? Think of experiments

or proofs that air has weight; that even gases lighter than air have weight.

Experiment.—Try to pick up with a magnet small bits of various solids, *e.g.* wood, paper, brass, iron, etc.

6. Which substances does the magnet attract? Which are not attracted by it? Compare this power with the attraction of the earth.

Note.—The power of the magnet to draw certain things is called *magnetism.* The power of the earth to draw all things is called *gravitation.* All the planets have the power of gravitation.

7. Of what benefit to man is gravitation?

8. What things are valuable because of their weight?

9. What things are useful because they have so little weight?

10. Do you ever hear of anybody being killed by the force of gravity?

11. How does the distance through which an object falls influence its speed and the force with which it strikes when it reaches the earth? Explain why this effect is produced.

12. How does distance affect the power of the magnet to draw things to it? Distance affects gravitation in the same way.

LESSON XX

TRANSFERRED MOTION

1. When riding in a street car or on a railroad train, what motion do things outside seem to have?

2. Have you ever been on a boat leaving a pier? Why does the pier seem to be leaving the boat?

3. Mention other experiences you have had where things seemed to be moving when you knew that they were standing still.

4. In what direction do such things seem to be moving as compared with your own course?

5. How fast did they seem to be going? What determines their speed in each instance?

6. If a car or a boat alongside of the one you are in happens to be going in the same direction and at about the same speed, what is its apparent speed? If it moves a little faster or slower than the one you are in, how will this seem to affect its speed?

7. Have you ever been in a car standing still in a station when a train on the next track began to move? In what direction did it make your car seem to move?

Note.—Such apparent motions are called *transferred motions.*

8. Under what conditions will there be transferred motion?

9. What determines its direction? its speed?

10. Apply this law to the daily motions of the sun, moon, and stars. Why do they all seem to move from east to west at the same speed?

11. What is the real daily motion of the earth?

12. Why does not the "big dipper" rise and set? What is it apparent daily motion? Explain it.

13. How may the real motion of any of the heavenly bodies be determined? (Recall the study of the moon, Lesson 24, Grade 5.)

14. Explain the apparent annual movement of the sun north and south, causing the seasons.

LESSON XXI

ECLIPSES

1. In what direction does the moon really travel? (See Lesson 24, Grade 5.) How long does it take the moon to complete its course?

2. Explain the phases of the moon.

3. Can you ever see the moon in the *dark* of the moon? In what part of the sky is it then?

AN ECLIPSE OF THE MOON

4. Is the moon's path near that which the sun seems to take? Which is nearer the earth, the sun or the moon?

5. If the moon should come between us and the sun, what would be the effect? This is called an *eclipse.*

6. At what time of the year do eclipses of the sun occur?

During what phase of the moon must it be, when an eclipse occurs? Why?

7. Make a drawing or use objects to illustrate how eclipses of the sun occur.

Note.—If the moon passes directly between us and the sun, cutting off all the light of the sun, it is called a *total* eclipse. If it passes above or below the center of the sun, cutting off only part of the light, it is called a *partial* eclipse. Sometimes it happens that the moon passes over the center of the sun, leaving a circle of light all around it. This is called an *annular* eclipse.

8. Have you ever seen an eclipse of the moon? During what phase of the moon did it occur? What were the relative positions of the sun, moon, and earth?

9. The earth, like other opaque bodies, casts a shadow. What effect will it have upon the appearance of the moon if the latter runs into the earth's shadow?

Note.—In this way the moon also may have eclipses similar to those of the sun.

10. Illustrate by drawings, or in some other way, eclipses of the sun and of the moon.

LESSON XXII

METEORS AND COMETS

1. Describe a shooting star.

2. How many shooting stars can you count in half an hour on a clear night? Try it and report to the class.

3. Why can we not see them in the daytime? Can we see as many in the city as in the country? Why?

4. Are shooting stars more frequent in one part of the sky than in another?

5. From your own observations compute how many shooting stars there will be in the part of the sky that you watched, in one hour; in all night; in twenty-four hours.

6. What portion of the whole sky would you observe at one time? Suppose you could watch one eighth of the sky, what would be the total number of shooting stars in half an hour? in an hour? in a day?

7. Are shooting stars or *meteors* all of the same size or brightness?

8. Do all travel an equal distance across the sky before they disappear? Do some seem closer than others?

9. Have you ever seen or heard of a meteor falling to the earth?

10. What do you think meteors are made of?

A METEOR THAT FELL IN NORTH CAROLINA

Note.—Meteors have often fallen to the ground. They are composed of earthly matters — sometimes of almost pure iron. They are thought to be fragments of a broken earth that are floating in space, and when the earth meets one in its rapid course around the sun, gravitation draws the meteor toward the earth with such great rapidity that the friction caused by passing through the air creates heat enough to make the meteor white hot and in many cases to burn it entirely. Occasionally part of a very large one will reach the ground, but only the most refractory portions of the original piece will remain unburned to reach the earth.

11. What two comets were seen in 1910? Describe Halley's comet, and tell what you can about it and its discoverer.

12. How do comets differ in their movements from other heavenly bodies? How do they differ in appearance?

HALLEY'S COMET, 1910

From a photograph taken at Lick Observatory, California.

13. Do you think from their appearance that they are solid bodies like the earth or the moon?

14. What do you think is the chief difference between comets and the planets that you have seen?

Note. — The paths of all the planets are known to astronomers, who can tell exactly how long it takes each to pass over its circle around the sun. Comets, however, move in irregular paths, and sometimes appear when not expected and fail to appear when they are expected. Little is known of their structure or use in the universe, but they are supposed to be made of gases and of small floating particles of matter highly heated and giving off the light that enables us to see them.

LESSON XXIII

THE TIDE

1. How often does the tide rise and fall? Describe the tide.

2. In what ways is it a benefit to man? What class of people are most affected by it?

3. How is the tide sometimes detrimental to man? Give examples to illustrate this fact.

SCENE AT LOW TIDE

4. Is the rising of the tide always uniform? Does the weather affect it?

5. When the tide rises highest, in what quarter is the moon? When it is the lowest, in what quarter is the moon?

6. Can you tell beforehand when the tide will rise and when it will fall?

7. Can you foretell when the tide will rise high and when it will be low?

8. Is there any relation between the high and low tides and the positions of the moon? Make careful observations before deciding this question, if there are tides near enough for you to observe, or if you can get reports about the tide.

THE SAME SCENE AT HIGH TIDE
(See illustration on page 157.)

9. If it be true that planets attract each other and that the moon attracts the earth, which will show the force of the moon the more, the land or the water? How will the latter show it?

10. Which will draw the more, a small magnet or a large one? a small planet or a large one? the moon or the sun?

11. How does distance affect the power of a magnet? Compare both the size and the distance from the earth of the moon and the sun, and make the best estimate that you can of their attraction on the earth.

12. If these two bodies were in line with the earth and on the same side of it, what effect ought they to have upon the tide? If they were on opposite sides of the earth, how would they affect it?

13. When are they in these positions? Do the tides show their influence?

14. When the moon is in the first and the third quarter, what kinds of tides are there?

15. In what direction do tides travel? Infer a reason.

16. Are the tides as high on the Pacific Coast as they are on the Atlantic? Explain any difference there may be.

17. Why do tides often rise much higher in a bay or other inlet from the ocean, than on a long, open coast?

LESSON XXIV

ICE AND SNOW

Experiment 1.—Put a small clear bottle filled with water where it will freeze during the night. Examine and describe the crystals formed: their size, shape, and position.

1. Notice the first crystals that form on freezing water. Compare them with the crystals seen in snowflakes and in hoar frost.

2. What makes the water turn to ice? Mention other liquids that become solids when they get cold enough. Which require great cold? Which require little cold?

3. Which of them form crystals as they cool? Which do not?

Experiment 2.—Place a piece of ice in water and notice how much sinks below and how much remains above the surface.

4. How does the weight of ice compare with that of water? Explain how this can be.

5. Why did the bottle in Experiment 1 burst? What other things have you seen broken by the force of water turning into ice? How are water pipes protected from being broken from this cause?

6. Why is it a good thing that ice floats on top of water? What would be the results if ice sank to the bottom as soon as it formed?

7. What great good in nature is the result of water expanding as it freezes?

8. At what temperature does water freeze? At what temperature does ice melt? Arrange an experiment to determine this.

9. Do fresh and salt water freeze at the same temperature? Test them.

10. What liquids can scarcely be frozen?

11. What liquids freeze or turn to solids while still very hot?

12. How is artificial ice made? If possible, visit an ice factory and become acquainted with the processes and principles used there.

Experiment 3.—Place a few drops of alcohol in one palm and an equal amount of water in the other and notice which evaporates the more rapidly. Also notice which hand feels the colder.

13. Which absorbs heat from the hand the more rapidly? What effect has this upon the temperature sense? (See Lesson 26, Grade 4.)

14. What effect has rapid evaporation upon temperature? Give many illustrations.

Note.—To make ice, some volatile liquid, such as ammonia or ether, is made to evaporate in iron pipes from which most of the air

is removed to aid evaporation. These pipes are submerged in large tanks of salt water and soon lower its temperature below the freezing point of fresh water. Cans filled with the latter are suspended in the salt water and soon become so cold as to freeze solid, forming the blocks of artificial ice that one sees in the ice wagons.

15. Mention some uses of ice to man: some uses of it in nature.

16. Tell how natural ice is cut and stored from rivers and ponds.

CUTTING ICE ON THE KENNEBEC RIVER, MAINE

17. What care should be taken to have pure ice for use in our homes?

18. Suggest how snow may be formed. What must be the conditions in the upper regions when vapor is converted into snow?

19. In what states of our Union does most snow fall? In which does snow never fall? Why?

20. How does altitude affect the snowfall?

21. Define the "snowline." Explain it.

22. Why are the highest mountains even in the tropics always covered with snow? Where is the ground always covered with it?

23. What are the uses of snow in nature? Mention all its uses to man that you can think of.

24. How deep have you seen snow? What harm is sometimes done by it?

LESSON XXV

HOUSE PLANTS IN THE WINTER

1. Visit a florist's and go through his greenhouse.

2. Name the plants that you find blooming there.

3. What care does he give to different kinds of plants? Consider the soil provided; the heat and moisture and how they are secured; the arrangement of the plants in beds and pots; the supply of sunshine and air, etc.

4. Are any of the plants troubled with insect pests? If so, how are these destroyed?

5. Are any useful insects ever allowed in the greenhouse?

6. What seeds and bulbs has the florist planted for spring blooming? What treatment are they receiving?

7. Is he raising any plants from slips? Name them.

8. What plants are most profitable for the winter trade? for the spring trade?

9. What plants can you raise at home in the winter? What plants have you growing there now?

10. Tell how different house plants should be treated during the winter. Which may be kept dormant in the cellar all winter?

11. What window plants have you in the schoolroom?

12. What plants that grow in the flower garden in the summer must be brought indoors for the winter? Which may remain in the garden if given special care and protection?

13. Wrap the tenderest plants in the garden with straw and burlap to protect them from the severe frosts.

14. Study flower catalogues and select a few varieties of flowers to grow at home and at school. Learn to recognize and name as many house plants as you can.

Experiment.—With but little trouble a Chinese lily may be made to grow at school. Place a bulb in a bowl of gravel and keep it wet. Watch the growth of the roots, leaves, and flowers. The decrease in the bulb, as development proceeds, is due to what?

LESSON XXVI

THE NATURE OF SOUND

Experiment 1.—Suspend a match across two fingers that are slightly separated, and touch it from underneath with a tuning fork that is sounding. Repeat with the tuning fork silent. Account for the difference in the results.

Experiment 2.—Touch a sounding tuning fork to the still surface of a glass of water. Account for the fine spray and ripples. Repeat the experiment with the fork silent. Why are the results different?

Experiment 3.—Touch the tuning fork first when sounding and then when silent and note and account for the difference in results: *a*, to a pith ball or glass bead suspended by a string; *b*, to the teeth; *c*, to the end of the tongue.

Experiment 4.—Stick a tack or a triangular piece of tin to one prong of a tuning fork with wax. Sound the fork and pass it quietly over a piece of tin foil or smoked glass, gently touching it. Account for the dotted line if held one way and for the zigzag line if held the other. A lens will make the line plainer to the eye.

1. All these experiments prove that sound is produced by what? Think of other experiments of similar nature.

2. Explain the vibrations when a bell is sounding; a drum; a musical instrument.

3. Compare the sound of a bell and the noise of a firecracker. Why is one continuous and the other not? What causes the vibrations in each case?

4. Compare the sound of a tuning fork with the rattle of a wagon over a stony street, both being continuous. Consider the nature of the vibrations as to regularity, frequency, quality, and uniformity.

Experiment 5.—Rub the teeth of a comb very slowly with a pencil. You can count the sounds. Rub the pencil over them with increasing rapidity—a musical note is produced.

5. What is the essential difference between a musical sound and a noise?

6. If the teeth of the comb were made in different sizes and each produced a different kind of sound, could a musical note be made in the manner described? Why? Give illustrations of musical sounds and of noises.

LESSON XXVII

TRANSMISSION OF SOUND

Experiment 1.—Shake one end of a rope stretched along the floor (a skipping rope will do).

1. How do the waves started at one end travel to the other?

2. Notice how the waves on a vessel, or better, those on a pond of water, spread outward in all directions from the center of disturbance.

3. In transmitting this wave motion, do the particles of rope or of the water move far? Describe their movement.

4. What is the difference between transmitting motion and moving?

Experiment 2.—(For the Teacher.) Place five or six pupils of about equal size in a row, facing from you. Let each, except the last, place both hands firmly on the shoulders of the one in front of him, keeping the arms rigid. When all are in position, give the first pupil a gentle but sudden push. The force is communicated from one to another until it reaches the last, who manifests it more than any of the others as there was no one to whom he could transmit it.

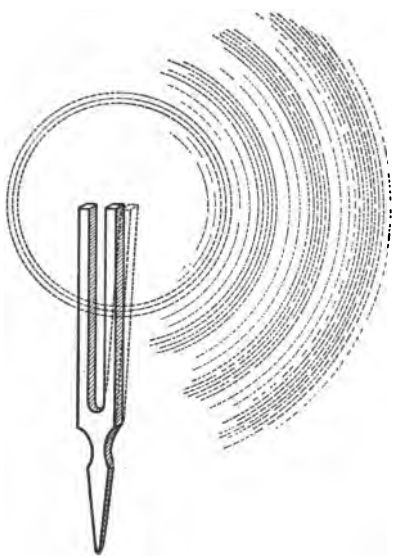
5. Give other illustrations of the transmission of force and motion.

Experiment 3.—Place a row of marbles in the pen trough on your desk. Strike the first against the second and explain how the last one becomes affected.

Note.—The air is made up of small particles which transmit the wave motions of sound from their source to the ear.

6. If sound waves traveled only in straight lines, as do the waves of the rope, what would be the result?

7. If they traveled on in a horizontal plane,



SOUND WAVES

As the prong of the tuning fork flies to the right, it compresses the air and sends out a wave; but, instantly flying back, it creates a partial vacuum that follows the wave, like the alternate crests and troughs of waves on water.

as the waves of water seem to do, where would the ear have to be to hear the sound?

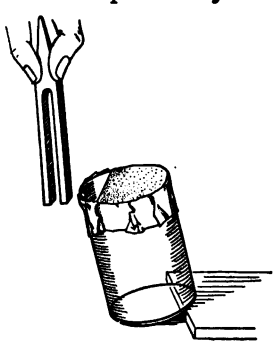
8. Why can we hear a sound in all directions from it? How do sound waves travel? What effect has distance upon sound?

9. Explain the use of speaking tubes and megaphones.

10. The sound of the human voice has been known to start an avalanche in the Alps. Explain how this could occur.

11. Why will the report of a pistol in a room sometimes put out the lights?

12. Explain why the explosion of some powder magazines broke nearly all the windows in a near-by city.



Experiment 4.—Wet a piece of thin strong writing paper, paste it over a glass tumbler, and let it dry. Cut an opening of the proper size at one side, sprinkle sand on the paper, tilt a little, and bring a sounding tuning fork near the opening. The sound will be augmented and the sand will roll downward.

13. How does this prove the nature of sound and that the air transmits it?

14. Think of other proofs that air transmits sound.

LESSON XXVIII

MEDIUMS OF SOUND

1. Why can a watch placed under the bell glass of an air pump be heard to tick before, but not after, the air is exhausted?

2. In the first three experiments of the last lesson, what effect upon the transmission of the motion would it have to remove a portion of the rope, pupils, or marbles, respectively, from between the two ends? Why?

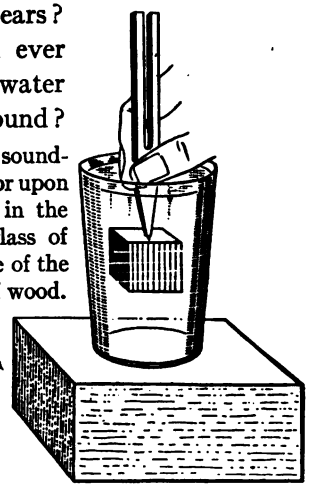
3. Illustrate by other examples the necessity of a continuous medium throughout for the transmission of any form of motion or force.

4. Does sound pass through water? How do you know?

5. Do fishes hear? Have they ears?

6. When in bathing have you ever struck two stones together under water and tried to hear if they made any sound?

Experiment 1.—Place the handle of a sounding tuning fork on an empty chalk box or upon any sounding body. Note the change in the loudness of the sound. Now place a glass of water on the box, and thrust the handle of the tuning fork firmly into a small piece of wood. Strike the prongs of the tuning fork to make it sound, and place the wood in the glass of water.



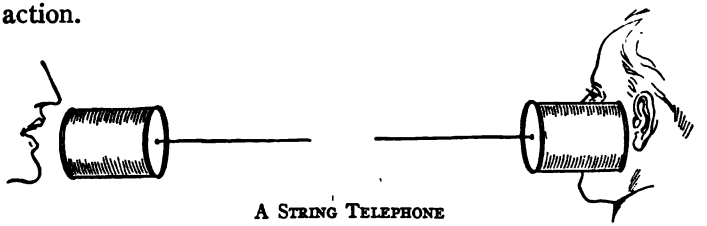
7. How does this experiment prove that sound travels through water? Think of other proofs.

8. Prove that sound travels through wood and through other solids.

Experiment 2.—With a sounding tuning fork pressed against one end of a wooden rod, put the other end to your ear, or against a door, and note the loudness of the sound.

9. Did you ever put your ear to the rail to hear a distant train? Why does an Indian often put his ear to the ground when hunting wild game?

10. Make a string telephone. Use it, and explain its action.



A STRING TELEPHONE

Melt the tops off two tin cans and pierce a hole through the bottoms. Pass a long string through these holes, tying a knot on the end inside of each can. Stretch the string and even faint whispers will be conveyed quite a distance. If an animal membrane be used instead of the tin can bottom, the results will be much more perfect.

LESSON XXIX

VELOCITY OF SOUND

1. You see the flash of a distant gun, or the puff of a steam whistle; later you hear the sound. Explain the interval.

2. A man seen at a distance chopping wood, or driving a nail, lifts his tool high after a blow before you hear the sound. Why?

3. Explain why the rolling thunder reaches your ears so long after you see the flash of lightning that caused it.

4. Mention other illustrations of this law of sound.

Experiment.—Let a person some distance from you on a railroad track strike the rail. You hear two sounds in quick succession. Why?

5. Can you think of any evidences that sound travels at different rates through different mediums?

Note.—Careful experiments prove that sound travels through the air at zero, 1090 feet in a second; at 60 degrees, 1120 feet in a second. In the same time it travels through oxygen gas, 1040 ft.; through hydrogen gas, 4160 ft.; through water, 5000 ft.; and through iron, 16000 ft.

6. If six seconds intervene between seeing the lightning flash and hearing the thunder that it causes, how far away was the lightning?

7. A certain warship is three miles away; what time will intervene between the flash of one of its guns and hearing the sound that it causes?

8. Make and solve five problems illustrating the application of this law.

9. Do you know of instances where a knowledge of the velocity of sound has been useful to any one?

10. What effect has distance upon the intensity of sound? Compare with light and heat in this respect. (See Lesson 3.)

LESSON XXX

REFLECTION OF SOUND

Experiment 1.—While some one is speaking, or blowing a mouth organ, or making any uniform sound, place your hands behind your ears and then in front of them. Describe the effect of each movement upon the sound.

1. Why do rabbits raise their ears when frightened at a sound?

2. Have you ever seen "sounding boards" behind pulpits or band platforms? Explain how they direct the sound.

3. How does an ordinary ear trumpet refract or bend the sound?

4. Why do we place our hand behind our ear when we wish to hear distinctly?

5. What animals have the external ear very large? Infer a purpose.

6. Account for an echo. What conditions must exist to form an echo?

7. Where have you heard echoes?

8. Which echoes more, a furnished house or an empty one? Why?

9. In an echo what determines the apparent direction of the origin of the sound? Is it the true direction?

10. Mention places that are remarkable for echoing.

11. Why is Echo River in the Mammoth Cave, Kentucky, so named? Tell what you may have heard or read of it.

12. Has the dome shape of the ceiling in the Tabernacle in Salt Lake City anything to do with its wonderful acoustic properties? A pin dropped on the pulpit can be heard in the gallery at the opposite end of the building 200 feet distant.

13. The sails of a vessel far out at sea have been known to catch and reflect to the crew the sound of church bells ringing on land.

Experiment 2.—Drop a pebble on to the still surface of a pond, or on to that of a large pan of water, and notice carefully, as the first waves travel toward the edges, if they rebound and return upon striking.

14. What kind of surface causes most definite return waves? What determines the direction of the return wave?

15. Apply the same principles to sound waves and to echoes.

LESSON XXXI

PITCH AND LOUDNESS OF SOUND

Experiment 1.—Pass a pencil over the teeth of a long comb at different rates of speed and note if there are corresponding differences in the pitch of the sounds produced.

1. When does the pitch seem highest? lowest?

2. When set in motion, which will vibrate the faster, a long cord or a short one? If a clock runs too fast, do we shorten or lengthen the pendulum? If a watch goes too fast, is the hair spring shortened or lengthened?

3. What notes are made by the long strings or wires in a piano? The short ones produce which notes?

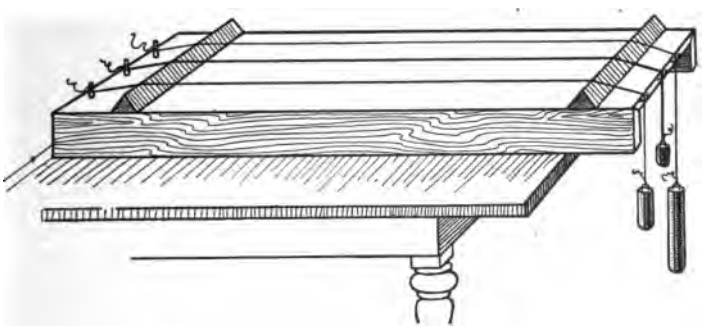
4. How is the pitch of a violin string affected by placing the finger down firmly upon it, thus shortening the vibrating part?

5. Do the long or the short pipes in an organ give high notes?

6. The pitch of a musical note, then, depends upon what?

7. The length of any vibrating body has what effect upon the speed of the vibrations? Give other illustrations of these truths.

8. Which will vibrate the more rapidly, other things being equal, a thin cord or a thick one? Give illustrations.

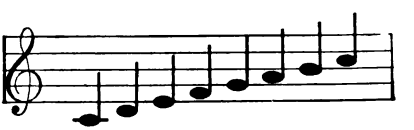


Experiment 2.—With an apparatus such as is in the illustration, by using cords of different sizes, and different weights, and by placing the "bridges" at various distances, demonstrate the effects of size, length, and tension of cords upon the pitch of the sounds that they produce.

9. Tell which cords produce the low notes, and why, in each of the following instruments: a violin, a guitar, a mandolin, a piano. Which produce the high notes?

10. What effect will the tension have upon the vibration of cords? If a violin string is too low, is it made looser or tighter? Give other illustrations.

Note.—By means of an instrument called a *siren*, which is made to produce a certain number of vibrations with each revolution, the number corresponding to each note of the musical scale can easily be determined, as the siren may be made to revolve at such a speed as to produce any desired note. The following table shows the notes of the musical scale, the names, and the number of vibrations corresponding to each note:

Staff and Position	
Number in scale	1, 2, 3, 4, 5, 6, 7, 8,
Letter names	c, d, e, f, g, a, b, c,
Syllable names	do, re, mi, fa, sol, la, si, do,
Relative number of vibrations	256, 288, 320, 341, 384, 426, 480, 512

11. How may the sound of a tuning fork be made louder?

12. When you strike it harder, what change is caused in its vibrations? Can you imagine also the change in the waves of air produced?

13. Does loudness increase the pitch? Why?

14. What change must take place in sound vibrations to make them louder? Illustrate this by several examples.

15. Explain how sound vibrations are produced in the following and in other similar objects: violin, mouth organ, flute, whistle, drum.

16. Explain the howling of the wind, the rolling of thunder, the buzzing of bees, the roar of a waterfall, etc.

17. Is the pitch of a locomotive whistle the same when approaching rapidly as when it is receding? Explain.

LESSON XXXII

THE HUMAN VOICE

Experiment 1.—Place the fingers upon the larynx and pronounce slowly *a* — *e* — *o*, etc.

1. Can you feel any vibrations?

2. Is the breath passing outward or inward as the sound is made?

3. How are the notes of an organ produced? Take off the reed covers of a toy mouth organ and explain how the air acts upon the reeds to produce sounds.

Note.—The air within the lungs is forced out as desired, and passing through the windpipe reaches the larynx or voice box. Here at will the strong delicate muscles called the *vocal cords* are stretched across the passage in such a way that the air in passing them causes them to vibrate. These vibrations are modified into speech and other sounds by the palate, tongue, teeth, and lips.

Experiment 2.—Change the sound of *o* into that of *e* and notice how it is done. Then change it into *v*. Produce various oral elements and describe the position of the organs of speech in connection with the voice and breath until you understand their actions.

Experiment 3.—Sound *do* of the musical scale. Raise it an octave and describe the change in the vocal organs.

4. Why is the chin liable to be extended in sounding a very high note? What movement takes place in the larynx?

5. Explain how these movements affect the vocal cords and therefore change the pitch.

6. Why do you draw in a full, deep breath when you wish to shout? Notice how the breath is exhaled in shouting.

7. Explain how the voice is made louder.

To THE TEACHER.—A proper description of the lungs and vocal cords should be given with this lesson, aided, if possible, by good anatomical charts or specimens.

8. Upon what does the strength of the voice depend? How may its strength be increased?

9. Since proper exercise of any organ of the body seems to be necessary to its growth and development, suggest how the larynx, chest, and abdominal muscles may be strengthened.

10. What effect may it have upon the voice to speak or to sing too long or too loud?

11. Why should the chest be kept full of air when speaking or singing?

12. What injury may be caused by wearing tight clothing about the neck, chest, or abdomen?

13. Is tobacco smoke a good thing for the voice?

14. How would alcohol affect the vocal cords?

15. What makes us hoarse when we have a cold? What is the condition of the vocal cords at such times?

16. Why is a man's voice deeper than a woman's?

LESSON XXXIII

THE EAR—HEARING

1. Describe the *external ear*.

2. From its shape and position infer its use in hearing.

3. Describe the *middle ear* or *auditory canal* leading to the inner ear where are found the nerves of hearing.

4. Compare its use to that of a speaking tube.

5. Account for the bitter wax secreted by its walls.

6. Are the hairs that are often seen near the opening of any use?

7. Should an insect enter the ear what harm might it do? Suggest a good thing to do in such a case.

Note.—Pouring a little oil into the ear is one of the best ways to kill the insect without injury to the ear. The obstruction can then be easily removed.

8. Study a good chart showing the anatomy of the ear and trace the transmission of the air vibrations through its various parts until they are received by the auditory nerve.

Note.—At the bottom of the auditory canal is the drum of the ear, a delicate membrane, which receives the vibrations from the air and transmits them to the inner ear through a chain of four little bones to a *labyrinth* filled with a watery fluid. In this fluid the nerve of hearing floats and takes cognizance of any vibrations given to the liquid and carries the sensation to the brain. This is how we hear.

9. Compare the various parts of the ear and the work that they do to apparatus used in explaining the principles of sound, *e.g.* the external ear, to various sound reflectors; the auditory canal, to a speaking tube; the drum, to the instrument from which it was named, or to the paper pasted over a tumbler (See Lesson 27); the bones of the ear, to various solids used to carry sound; the liquid in the ear, to that in the glass tumbler, etc. (See Experiment 1, Lesson 28.)

10. Consider the results if any of these parts of the ear

are injured or destroyed. What dangers often impair hearing?

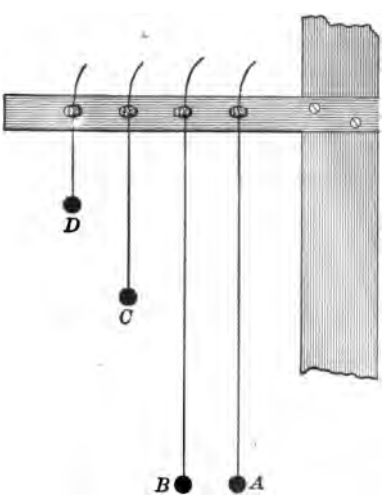
11. What care should we take of this special sense?

12. Is it a good mode of punishment to "box" or pull a child's ear? Why?

LESSON XXXIV

THE PENDULUM

Experiment 1.—From any convenient form of support, suspend four pendulums made by fastening lead balls to the ends of strong threads. Make two of them, *A* and *B*, a yard long; one, *C*, half a yard long, and the fourth, *D*, quarter of a yard long. Vibrate *A* and *B*.



1. Do pendulums of the same length vibrate in unison? Explain why they continue to move to and fro. What brings them finally to rest?

2. Vibrate *A* and *B* so that one moves over about twice as much space as does the other. Do they now vibrate in unison?

3. The distance a pendulum moves from its point of rest is called its *amplitude*, and its to and fro movement once over its path and back is called an *oscillation* or *vibration*. Does the amplitude influence its time of oscillation?

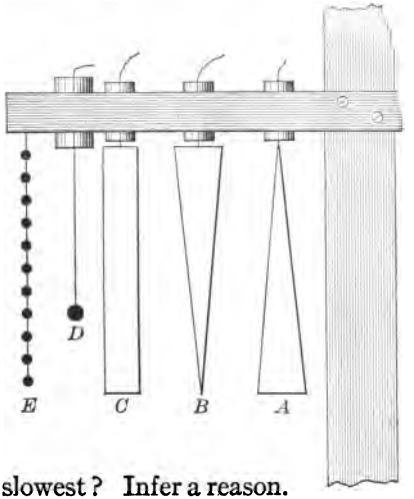
4. Vibrate *B* and *C*. Which moves the faster? Why? Does *C*, which is half the length of *B*, move just twice as fast as *B*?

5. Vibrate *B* and *D* and count the number of oscillations that each makes in one minute. Compare them.

6. Can you see any definite relation, or law, between the length of pendulums and the times of their oscillations? If so, state it.

7. For what are pendulums most used? About how long is a pendulum that will oscillate once each second?

Experiment 2.—Suspend in a similar way, as before, five pendulums: *A*, *B*, and *C*, made of wood and shaped as in the illustration; *D*, a lead ball; and *E*, made by cutting gashes in small bullets and pinching them upon a thread. Vibrate them in pairs.



8. Do they all vibrate in the same time?

9. *A*, *B*, and *C* as sticks are all the same length; as pendulums, are they the same length? Which vibrates the fastest? the slowest? Infer a reason.

10. Vibrate *E* by drawing it aside and letting it swing. Do the balls form a straight line or a curve? Explain.

11. The length of any object, as a pendulum, is determined by what?

12. Regulate the length of *D* so that it will vibrate in turn in unison with each of the other pendulums.

13. Think of an experiment, and perform it, to find out if pendulums having the same length but different weights will vibrate in unison.

14. How is a pendulum clock regulated when it is gaining time? When it is losing time?

15. What takes the place of a pendulum in watches and in some clocks? On what principle are such timepieces made to go slower or faster?

SEVENTH GRADE—SPRING WORK

LESSON XXXV

STUDY OF FOODS

OBSERVATION WORK.—Visit a grocery store; a green grocer's; a fish market; a meat market; a bakery, etc. Make lists of the different articles for sale in each, and note the quality, conditions, prices, and methods of caring for and handling the various stuffs.

1. Which is the best grocery store in your neighborhood? Why? Consider cleanliness, neatness, order, completeness of stock, quality of goods, prices, service, etc.

2. Compare in a similar way the other places visited.

3. Name the different kinds of meat sold in the meat market. From what part of the animal are the various cuts taken? Account for their difference in price. Tell what you know about cooking different kinds and cuts of meat.

4. Name the various kinds of fish on sale at the fish market. Where is each kind caught? Compare and account for the differences in price of the different kinds. Tell what you know of a fisherman's life and labors.

5. Visit, if possible, a flour mill and learn how wheat is

cleaned, ground, "bolted" or separated into its different parts, and put into sacks or barrels for market. Compare with the old-fashioned ways of making flour.

6. Visit also a large bakery and study the processes of turning the flour into bread. Mention other food products found in a bakery and tell how they are made.

7. Where do the dealers in food products obtain what they sell? How do the prices they pay compare with the prices they charge? Why should there be a difference?

8. Make a list of products that come from the farm. Tell what you know about how they are produced and marketed.

9. What foods come from the ocean? Tell how they are secured and marketed. Tell what foods are found in rivers; in marshes; in mountains; in forests.

10. Where is the great wheat belt? the corn belt? Describe a grain elevator and the shipment of grain.

11. Where do the different fruits found in the market grow?

12. Where are there great market gardens that supply us with vegetables? What vegetables grow in the ground? above the ground?

13. What states produce the most mutton? Where are most beef cattle raised?

14. Visit and study the processes of any near-by establishment engaged in producing or manufacturing food supplies, and discuss them in the class.

15. Make a special study of any one of our common foods and the processes used in raising it, preparing it for market, and for the table.

To THE TEACHER.—Several lessons may be devoted to this work. Different pupils may be asked to prepare different topics and make reports to the class, illustrating their reports with pictures and samples.

LESSON XXXVI

THE STUDY OF FOODS (Continued)

1. Make separate lists of all the mineral foods, animal foods, and vegetable foods that we eat.

2. Which of the three great kingdoms of nature furnishes us with the largest list of food materials?

A Lesson in Cooking—Utah State Normal Training School

3. How may these lists vary with the seasons? Which kind of food do we eat a great deal of in the summer but less of in the winter? Which kind do we eat in winter but not in summer?

4. Which are necessities? Which are luxuries?

5. Which foods contain much water?

Experiment 1.—Weigh carefully 10 grains of each of the following kinds of food: potato, apple, turnip, banana, fish, grapes, or other foods conveniently obtained; dry them thoroughly in an oven or other

suitable place, and weigh them again to find what has been lost through evaporation.

6. Test various articles of food for starch. (See Grade 6, Lesson 45.) Mention the principal foods that contain starch. These are called *carbohydrates*. Sugar also belongs to this class of foods.

Experiment 2.—Chew for a long time a piece of common soda cracker. Can you detect any change in the taste of it as it becomes a creamy liquid ready to be swallowed? Has some of the starch changed to sugar?

Note.—The saliva acts upon the starchy foods, and does much toward digesting them.

7. Why should we chew thoroughly all our foods and particularly the starches?

Experiment 3.—Take the white of an egg and mix it thoroughly with a pint of clear water, and filter the mixture, or strain it, through a fine cloth.

(*a*) Fill a test tube half full of the liquid and heat it over the flame. The white cloudiness produced is due to the coagulation or the hardening of the white of the egg which is almost pure *albumen*.

(*b*) Add a little hydrochloric acid to another portion of the mixture and note the same change.

(*c*) Repeat (*b*), using alcohol instead of the acid. These are three easy tests for albumen.

Experiment 4.—Wash all blood from a small piece of lean meat and mince it in a glass of clear water. Filter or strain the water as before, and test it for albumen.

8. Mention foods that contain albumen. These foods are called *proteids*.

Experiment 5.—Heat in a test tube or other convenient way a piece of meat without allowing it to burn. Add cold water and note what forms on the surface after it has stood a short time. This is a test for fats.

9. Test various foods for fat: nuts, olives, etc.

10. The *carbohydrates*, *proteids*, and *fats* are the three essential classes of foods, and every day's fare should contain its due proportion of each to supply all the needs of the body. Mention the various articles of food that you have eaten to-day and classify them as above.

11. Which of the three kinds furnishes the largest proportion of our diet?

Note.—Farmers' Bulletin No. 23, entitled "Foods: Their Nutrition, Value, and Cost," may be had upon application to the Secretary of Agriculture. It discusses in great detail this subject and should be found in every school library.

LESSON XXXVII

DIGESTION

1. What animals go the longest time without food? Compare their activity and the temperature of their bodies with those of animals that eat more frequently.

2. How does hard work or vigorous muscular activity affect our appetite? Infer a reason for this.

3. When do we eat the more, in hot weather or when it is cold? Why?

4. Why do we need food? How does it keep us alive?

5. How many pounds of food will an average man eat in a day? How much water will he drink?

Experiment.—Find out by actual test the amount and cost of the food you eat in a day and how much water you drink.

Note.—Including the oxygen of the air used in the body, a man consumes about one and a half tons of material in a year.

6. Can a person live long upon starchy foods alone? Why do we eat butter on bread, cream on oatmeal, cheese on macaroni?

7. Of what service is the water that we drink?

Nearly two thirds of our weight is water, and physicians say that we should drink more water than we do.

8. What foods do we relish in winter more than in summer? Infer their use in the body. Mention foods we like in summer. Why?

9. What important use has our appetite?

10. As all foods must be *assimilated* or prepared for their particular use in the body, they are put through an elaborate process called *digestion*. What is the first step in digestion?

11. Describe *mastication*, and tell all that happens to the food in the mouth.

12. What evils result from poor teeth? from very rapid eating? from wetting the food with tea, coffee, or water?

Note.—Three pairs of saliva glands furnish enough fluid to reduce the food to a liquid state so that it can pass on with ease; at the same time by its chemical action the saliva gives important assistance in digesting the food.

13. Describe the act of swallowing. Compare it with the way that other animals swallow.

14. Tell what you can of the work done in the stomach. If possible, compare the stomachs of the pig, hen, and sheep, and learn how each is adapted for the different kinds of work that it does.

Note.—In the stomach *gastric juice* is added to the food and mixed with it thoroughly. When properly prepared, it then passes through the *pylorus* into the *intestines*, where it receives *bile* and *pancreatic juice* to aid further in dissolving the different kinds of food. As portions become properly assimilated, they are absorbed by certain glands

of the intestines and conveyed to the *thoracic duct*, which empties the food into one of the large veins. The blood in its circulation then carries it to all parts of the body and each tissue extracts what it needs.

To THE TEACHER.—These internal processes should be studied and explained with the aid of good anatomical charts and specimens. Comparisons should be made also with the digestive organs and processes of other animals.

15. Compare the *mucous membrane* of the mouth and throat with the skin on the outside of the body.

16. If alcohol burns the mouth and throat severely in quickly passing through them, how will it affect the membranes of the stomach and the intestines, where it remains much longer?

17. Alcohol is not digested. It passes unchanged into all the tissues of the body as alcohol. How will it affect the delicate cells of the heart? the lungs? the brain? As there is albumen in most animal tissues, recall the effects of alcohol upon albumen. (See Experiment 3–c, Lesson 36.)

18. How does the body in its various organs respond to the use of intoxicating drinks? Tell what you know of the evils of drinking.

19. How does the first use of tobacco affect a person? What does this prove regarding its use? Mention evils coming from its uses.

20. Why are there laws in all civilized nations against the use of narcotics?

LESSON XXXVIII

PURE AND ADULTERATED FOODS

1. What foods sold on the market are adulterated or unfit for use? How can such foods be detected?

Experiment 1.—Get a pint of milk known to be pure, and fill a long test tube with a portion of it; set it away in a clean cool place for a day, and then notice the changes in color of its different parts.

2. What part of the whole is cream?

3. Is there any sediment in the bottom? Examine carefully.

Note.—Ordinary milk should contain 10% of cream. That from a Jersey cow may contain two or three times as much. The amount of cream in milk is a test for its purity.

4. Add some water to another portion of the sample of milk and dip into it the end of a clean knitting needle. How does the drop of the mixture that adheres to the needle compare in size with the drop when pure milk is used?

5. What is the difference in color between pure milk and that which has been diluted with water or deprived of its cream by a cream separator?

Experiment 2.—Test milk for fat and for albumen. (See Lesson 36, Experiments 2 and 4.)

6. What is made from cream? Describe how butter is made. If convenient, stir some cream in a test tube until butter is formed.

7. How is butter adulterated? What is butterine? How is it made?

8. What changes take place in milk when allowed to stand a day or so? How does temperature affect this change? Why should milk be kept in a refrigerator?

Note.—Milk turns sour because of an acid produced by *bacteria* that develop in it. Warmth hastens their growth.

9. Why do milkmen want to kill these bacteria?

10. Do you think that a drug that would kill the bacteria in milk would be a thing that a person ought to drink?

Note.—In warm weather milk sours so quickly, therefore becoming valueless, that dealers say they must use something to prevent these bacteria. In large cities it is claimed that adulterated milk is the cause of a very large portion of the deaths among infants.

11. Why are there public officers to test milk and other foods?

12. Tell what you know about state and national food laws, and the penalties for adulterating foods and drugs.

13. Why are public officers kept at all the stockyards to inspect all the cattle, sheep, swine, and fowls that are killed there for food? To what diseases are these animals subject?

14. What often renders fruits unwholesome?

15. What diseases are often found in vegetables?

16. Why is it dangerous to eat stale meats, fruits, and vegetables? Do you know of any one having been injured by doing so?

Note.—Scientists claim that undrawn fowls are not safe to eat after 48 hours, even if kept in cold storage, as it sometimes happens that animal parasites will work their way from the intestines into the flesh of fowls.

17. Mention examples of people who have been made ill by eating impure food.

18. Are drugs and medicines always pure? What do you know about ways in which they are adulterated?

19. Read the provisions of the food laws.

LESSON XXXIX

AGENTS OF EROSION

A Field Lesson.—If possible, visit a cliff beside a stream and study how the surface of the rock is breaking off into angular, sharp-edged fragments and piling as talus at the base. Notice also what

the stream is doing with the bowlders and pebbles in it, and estimate its power to carry and grind the stones in its various parts at times of high and low water. Visit the seashore also, and see what the waves are doing with the rocks and pebbles. Judge their power and work during a storm. Notice if the wind moves the sand, dashing it against cliffs and rocks or piling it into shifting hills.

In case visits of this kind cannot be made, collect good pictures of such scenes to study, and read illustrated magazine articles about them. (See Book 1, pp. 19 and 20.)

1. How does freezing aid in breaking up rock?

2. How are rock fragments ground smooth and round in the swift mountain streams? (See Lesson 44, Grade 4.)

3. Great bowlders are often seen in swift streams. How did they come there? How is the stream gradually wearing them away?

4. At times of high water have you heard them tumbling over and over as they roll slowly down the steep grade? What effect will their movements have upon the gravel that lies under them?

5. Strike the sharp corners of one stone with another and note the effect. Describe how streams wear stones.

6. How do the waves wear stones?

7. How may we distinguish river pebbles from ocean pebbles?

8. What becomes of the dirt ground off by streams? by the waves?

9. How may changes of temperature break up stones? Why will hot water break a cold glass? Why does a drop of cold water break a hot lamp chimney?

Experiment 1.—Heat a cobble very hot in the stove and drop it into cold water and see if it cracks anywhere.

Sudden changes of temperature have been known to break fragments from the face of a cliff.

WIND EROSION OF SANDSTONE (SAN JUAN COUNTY, UTAH)

The wind has been aided by the alkali contained in the sandstone, and by the rain, which has moistened it, causing it to eat into the stone.

10. What do you know of the work of the wind in driving sand against stony surfaces and wearing them? Under what conditions can such work be done?

In some places the window glass in fishermen's huts has been worn away by this action.

11. Describe the use of the sand blast in etching glass.

12. How do the roots of trees and smaller plants sometimes break open or disintegrate rocks? Describe work of this kind that you have seen. Examine the roots of trees and shrubs growing in stony places and report what you find to the class. Have you seen the pavement on sidewalks cracked and raised by the growth of the roots of shade trees?

THE SPHINX HEAD

A remarkable example of wind and water erosion in the Petrified Forest in northern Arizona. — Photograph by L. C. Snow.

13. Notice carefully the work of lichens and mosses growing on stones. Do they soften or disintegrate the surface?

14. Trace, if you can, how the lichen prepares stones for the growth of a succession of plants from lower to higher orders.

Note.—In securing mineral food for the plant, some roots secrete an acid that dissolves rocks in minute quantities and in this way they eat into the stony surfaces.

Experiment 2.—Evaporate a few drops of "city water" on a clean glass and account for the whitish residue.

Note.—Much stony material is dissolved by water, especially limestone. The presence in most water of carbonic acid gas adds much to its power as a solvent. (Recall the test for limestone, Lesson 39, Grade 6.)

15. In what kind of stone are most caves found? How came these hollows in the earth? What evidence of the action of water do most of them contain?

ROCK ERODED BY WIND AND SAND (NEAR LARAMIE, WYOMING)

16. Think of other ways in which water aids the disintegration of rocks.

17. Do any animals aid in this work of disintegration? Consider the work of burrowing animals, ants, earthworms, etc.

18. How do glaciers grind rocks and stony surfaces? Study the movements and forces of glaciers and their work in grinding earth materials.

19. How can you distinguish glacier-worn rocks from those worn by streams and ocean waves?

20. Tell how man aids in breaking up earth materials.

21. What general effects have all these agents of erosion upon the forms of the earth's surface as they work continuously for centuries?

LESSON XL

CARRIERS OF SEDIMENT

A FIELD LESSON.—Visit and study any convenient stream and consider its power to carry earth materials in its various parts in times of high and low water. Study the action of waves and tides upon sediment in the sea. Visit sand dunes and learn what work is done by the winds with soil materials; and from books, pictures, and magazine articles, study the work of glaciers in carrying rock, sand, etc.; compare their work to that of rivers.

1. What two conditions determine mostly the carrying power of streams?

2. How does a stream distribute its burden? Where will it drop the bowlders? the sand? the gravel? the fine silt? the cobbles?

3. Where is the water the swifter, at the edges or near the middle? Why? At the mouth or near the source of the stream? Why?

4. Account for the bends in a river; for the gradual change in its course; for the sand bars or islands in its bed; for the oxbow loops; for the delta at its mouth.

5. Form some estimate of the amount of sediment any near-by stream carries during high water time. How can you do this?

Note.—The Mississippi river carries enough mud every year to build a mountain a mile long, half a mile wide at the bottom, and five hundred feet high.

SEA CLIFF EROSION, PORT JEFFERSON HARBOR, LONG ISLAND.

(Photographs by Dr. Charles P. Berkey of Columbia University.)

1. Showing sliding sand, leaning trees, and the under-cut, or "nip," at the foot of the slope made by high tide. The nip is from 1½ to 14 inches.

2. Showing the nip partly filled with sand. This amount has rolled down in two days. In a few more days the slope will become smooth and the nip will wholly disappear.

3. Showing the nip, and the sand talus partially filling it up again. The nip wall is 20 inches high at this point.

4. Showing effect upon the tree growth along the top of the cliff, where the roots are being continually uncovered by the removal of sand that rolls down its slope. Many of the trees are still alive.

6. The water of the Amazon river colors the ocean for three hundred miles from its mouth. Account for this.

7. Why does not the Mississippi do the same? Consider the influence of the Gulf Stream upon these two rivers.

8. How do tides and waves act in forming sand bars and low islands along the coast near the mouths of rivers?

9. What happens to silt when the water carrying it becomes stationary?

10. From a study of the illustrations on pages 192 and 193, explain how the action of the waves wears away the coast. What makes the trees lean?

11. What general movement has the surface of the slope? How does vegetation hinder this movement?

12. Is this coast line now where it was a century ago? Explain.

13. Account for the Dismal Swamp of Virginia and for the Albemarle and Pamlico sounds. How did the ocean aid in their formation?

14. Compare the deltas at the mouths of the great rivers of the world and account for their form and size. Consult a good geography.

15. Study the formation and the movements of a glacier. How does it come to be the carrier of great bowlders as well as of finer portions of earth materials?

16. If the lower end of a glacier enters the ocean, what may become of the bowlders, etc., that it carries? If it descends into a valley where it melts, what becomes of the bowlders, cobble, silt, etc.?

17. Describe and account for the *lateral* and *terminal moraines*.

18. Explain the formation of icebergs. Are they made of fresh or of salt water? How may they become carriers of earth materials? Where will they deposit such materials?

19. Explain how sand is moved about and piled up by the wind. How may it fill up swamps and marshes?

20. How does vegetation sometimes stop this work of the wind? What harm is often done by sand dunes?

Note.—Farms and houses are sometimes buried in sand. In England many years ago the little town of Eccles was so completely covered that only the church steeple could be seen.

17. Tell what you know of the deposits of lava and ashes from the action of volcanoes. Such deposits of past ages have become the most fertile of soils through the action of natural agents.

18. Which of all these carriers of soil have done the most in preparing fertile soil? Where are the greatest fertile plains situated with regard to these workers?

19. How does organic matter get mixed with soil in the operations of nature?

20. Which of these carriers deposit sediment where the conditions may in the future turn it into stone again?

21. Which stones were once mud? sand? gravel? Account for their present condition.

LESSON XLI

FARM WORK IN THE SPRING

FIELD LESSON.—If possible, spend a day or more on a farm in the spring and study the conditions and activities to be seen there.

1. Describe the condition of the soil in early spring. How does it differ from its condition last fall? Account for the change.

2. Were any crops planted last fall? If so, what is their condition now? What advantage was it to plant them in the fall?

3. Describe the work being done now in the soil and its necessity. Consider fertilizing, plowing, harrowing, planting,

scraping and leveling the ground, cleaning and making ditches and drains, irrigating, etc.

4. What machinery aids the farmer greatly in his spring work? Describe the construction of the plow, harrow, corn planter, wheat seeder, cultivator, scraper, etc., and tell how each does its work.

5. What animals are most helpful to the farmer in this work? Mention good breeds of horses for farm work.

A Steam Plow

6. Compare the amount of work done now on the farm with the aid of machinery with what used to be done by hand. How has this improved the conditions of the laboring class?

7. How is the planting of seeds by machinery a great improvement over hand planting in other ways than the amount done?

8. What incomes has the farmer in the spring? Consider eggs, milk, butter, and crops not sold in the fall.

9. How is the land kept fertile year after year? Tell what you know about fertilizers and the methods of using them.

10. How is each crop planted? Give a reason for the depth, distance apart, and time of planting different seeds.

11. What care is taken in selecting seeds to plant? Why? From a seed store, get samples of various kinds of seeds. Examine them with a lens and determine which are pure and good, and which contain shrunken seeds and weed seeds.

12. Find out the care that each crop should receive during the summer and the reasons for plowing, cultivating, irrigating, etc., and the manner of doing the work.

13. Name and describe the various weeds that annoy

A Wheat Drill

the farmer. What are the best methods of getting rid of them and preventing them in the future?

14. What trees grow on the farm? Of what use are they?

15. Mention trees that make good wind breaks. Which are used for shade? Are any used for firewood? for lumber? What trees are used as ornaments?

LESSON XLII

THE STUDY OF FLOWERS

1. The flower is the most beautiful and wonderful part of a plant. Make a list of all the wild flowers you can recognize and name. How many cultivated ones do you know?

2. What uses do we make of flowers?

3. Of what use are they to insects and to other animals?

4. Suggest their uses to the plants bearing them.

5. Bring to the class several kinds of flowers to study. What is the use of the green unattractive leaves that cover the flower bud? Notice their color, thickness, position, surface, number, etc. These are called *sepals*, and the circle or envelope that they form around the flower is called the *calyx*.

6. As the flower opens, what becomes of the calyx? Why?

7. The circle of flower leaves within the calyx is the *corolla*, and the individual leaves are called *petals*. Note their number, color, arrangement, and beauty.

8. Why are flowers so beautiful?

9. What is there besides their beauty that makes them attractive?

10. When do the odors of flowers develop? How does their fragrance benefit them?

11. When and why do they develop nectar?

12. Remove the calyx and the corolla and examine the parts that remain. Use the trillium, anemone, apple or cherry blossom, or some similar flower. Within the corolla are how many knobbed stocks with yellow heads? These are called *stamens;* and their heads, *anthers*.

13. What part produces the pollen? What is its use to the plant? How does it do its work? (See Experiment in Lesson 43, Grade 6.)

14. The center organs of all are called *pistils*. Cut the flower bud open carefully and discover the relations between the pistils and the undeveloped seeds.

Note.—In most cases the seeds and fruit will not grow unless some pollen is made to fall upon the top of the pistil, where there is generally a sweet moisture to which a grain or two will stick. Here the pollen grains germinate in a short time and send downward a tiny growth, which in some mysterious way awakens the life germ in the seeds and causes them to grow and the fruit to develop. The pollen from some other plant of the same kind is better than its own.

Experiment.—Cover a cluster of flowers on some thrifty plant with a paper bag or with a piece of thin muslin, to keep away all insects, and note the difference this causes in the development of the seeds.

15. Watch bees and other insects entering and leaving flowers, and note carefully how they carry and distribute pollen. Draw a plan of a typical flower to illustrate the use of its different parts.

16. When the seeds begin to grow, what becomes of the flower organs? Why?

LESSON XLIII

THE STUDY OF FLOWERS (Continued)

1. What is the use to the flower of its perfume, nectar, and beautiful colors? At the times when these attractions reach their climax, what is the condition of the stamens and the pistils? Account for this coincidence.

2. Note the position of most flowers on their respective plants. Is there a purpose in their prominence?

3. Which develop first in the spring, the leaves or the blossoms? What design is evident in this fact?

4. Notice the shapes of different flowers. Which are adapted to accommodate visiting insects? Note also the shape and the size of the visitors. Are any insects repelled by the shape and the size of flowers? Find examples to illustrate the uses of the shapes of flowers.

5. Are all flowers provided with a full set of the floral organs described in the last lesson? Find examples of flowers lacking any of them.

6. Which of the organs are absolutely essential to the production of seeds? What is the office of each of the others?

7. Do all plants depend upon insects to distribute their pollen? Mention other ways of doing this.

8. Explain the absence of petals, perfume, and nectar from flowers whose pollen is distributed by the wind. Bring to the class samples of such flowers.

Note.—To the botanist all plants that produce seeds have flowers — but their flowers may not have beautiful petals. They will have the essential organs, however.

9. Find and study flowers that have no petals. How are their seeds fertilized? Make a special study of corn in this particular. Examine grasses, weeds, and forest and shade trees.

10. Find some flowers that have stamens and no pistils. Find others that have pistils and no stamens. Suggest a reason for separating these organs.

11. Examine flowers having both essential organs and see

if they are arranged to secure or to avoid self-pollination. Will the pollen fall easily upon the top of the pistil?

12. What proofs can you give from the structure of flowers that self-pollination is not desirable in nature?

13. Study different blossoms of the squash; the box-elder; the walnut; the strawberry. Find out how all the common flowers in your vicinity contrive to get their seeds fertilized.

14. What flowers have many petals? Which have few? Find examples of flowers having, instead of petals, a single trumpet-shaped tube. In what other ways is the corolla modified? Find examples.

15. Study also the different forms of the calyx. Is it ever wanting in flowers?

16. What flowers grow solitary on a twig? Which grow in clusters? Which grow cone-shaped around the stem? Notice how different varieties grow on their stems, and whenever possible assign a reason for the various ways in which they are arranged.

17. What plants group many of their flowers into a single head? Study the sunflower, and find other flowers constructed in a similar way. Such flowers are called *composite*.

18. As you study different flowers, group or classify them according to some striking characteristic.

Experiment.—With a feather or small water-color brush take off some pollen from the anthers of one flower and transfer it to the pistils of another of the same kind. Pollinate in this way different varieties: corn, tomatoes, sweet peas, geraniums, etc. Plant the seeds that develop from these experiments and note the changes wrought. This is the way hybrids are made; and often new and choice varieties are thus produced.

LESSON XLIV

THE BIRDS OF SPRING

1. Early in the spring make a list of all the birds that were winter residents in your locality, recording the food that they ate.

2. Keep a careful lookout for the return of the migratory birds and record the date of their first appearance.

3. What is the food of the first that appear?

4. What tender plants are appearing? What insects are beginning to awaken?

5. Which birds are mated? Which begin to build nests?

6. Describe the conduct of the birds, and their songs, chirping, and other noises.

7. Do you recognize any of the returning birds as former residents of your locality?

8. How old do birds live to be if allowed to live to die of old age?

Note.—Migratory birds often are known to return in the spring to their old haunts. Canaries sometimes live to be twenty years old.

9. If possible, find a nest and without disturbing it or the old birds, watch and find out all you can of their nesting habits. Observe and record the number of eggs; time taken to hatch them; the number of the young; the number of the times they are fed each day; kinds of food given them; and the habits of the old and the young.

10. Mention the uses of birds; the insects that they eat; the weeds that they destroy. Consider the songs they sing and the joy that their beauty and presence give.

11. What enemies destroy many useful birds? Consider hawks and other birds; cats, snakes, and other animals; men with guns; boys with stones, and the effects of using their feathers on ladies' hats.

12. Read the game and bird laws and give reasons for their provisions.

13. Classify birds as swimmers, waders, shore-birds, scratching birds, perchers, songbirds, birds of prey, and miscellaneous. Make as large a list as you can of each kind, and study their adaptations (especially as to head and feet) to their environment and methods of life. (See Lessons 39 to 44, Grade 3.)

14. Find out the damage done each year to the crops by insects that birds should destroy.

15. How can desirable birds be increased? What can you do for them?

EIGHTH GRADE—FALL WORK

LESSON I

CLASSIFYING KNOWLEDGE

1. What is a store? Name all the different kinds of stores that you can. What kinds of goods does each one carry?

2. To what kind of store would you go to buy sugar? a watch? an ax? a suit of clothes? towels? shoes? beefsteak? medicine? writing paper? cabbage? a rocking-chair? fruit?

3. Upon what is this classification of stores based? Of what use is this classification of stores?

4. Can you think of any other basis for classifying stores? Consider wholesale, retail, commission, secondhand, incorporated, etc., and give a use for each basis of classification.

5. Which basis has the widest use?

6. Define food. Name the different kinds of foods that we eat. Group them into classes according to some useful feature.

7. Which are vegetables? cereals? meats? fruits?

8. Which are animal foods? plant foods? mineral foods?

9. Which are starchy foods? fatty foods? albuminous foods?

10. Think of other ways of grouping foods and a reason for so grouping them.

11. In like manner, classify different industrial occupations, professions, studies, games, etc., and show wherein each classification serves a useful purpose.

12. Show the need of smaller classifications within each of the greater groups, *e.g.* the different departments in a clothing store, as men's clothing, boys' clothing, underwear, neckwear, hats, etc.

13. In a similar manner, and for similar reasons, all things in nature are classified. Into what three great kingdoms are all natural objects classified?

14. Mention ten common objects from each of these kingdoms.

15. Classify all the objects in the room into their proper kingdoms of nature. Classify those that can be seen out of the window.

16. What is the basis of this classification?

17. Explain some of its many uses.

18. Which may be called the highest of the three kingdoms? Why? The lowest? Why?

LESSON II

THE ANIMAL KINGDOM

To THE TEACHER.—The three succeeding lessons are designed to suggest a method of developing a more scientific study of nature; each lesson may be extended into as many lessons as time will permit.

1. What are the chief points of difference between plants and animals?

2. What forms of animal life most nearly approach plants? What forms of plant life most nearly resemble

minerals? Is there a wide line of demarcation between them?

3. What are the vital organs of animals? What acts must animals perform frequently in order to live?

4. Mention common groupings of animals based upon their structure. Describe the differences between the groups, and the resemblances among members of the same group.

5. What feature of structure would serve to divide animals into the largest groups? Which have a backbone? Which do not? Which have warm blood? Which have cold blood? Which bring forth living young? Which hatch from eggs? Think of other differences between various groups of animals.

6. Point out differences between the higher types and the lower types of animals.

7. Name animals that have a backbone and an internal skeleton. These are called *vertebrates*. Consider the advantage of this structure.

8. Which animals seem to be made up of similar parts joined together? These are called *articulates*.

9. Which animals are simply fleshy masses often protected by a hard shell? These are called *mollusks*.

10. Name some animals that have a central body with limbs running outward in many directions. These are called *radiates*. Most of the radiates, with many of the mollusks, live in the sea.

Note.—These are four of the subkingdoms of animal creation. Consider the differences and the resemblances of the groups and the members of the groups. Make a list of animals you know that belong to each group.

11. Suggest several great groups into which the vertebrates may be divided. Consider beasts, birds, reptiles, and fishes and their similarities and their differences.

12. Construct a diagram illustrating a simple scheme of classifying animals into greater and lesser groups based upon their physical structure.

LESSON III

THE VEGETABLE KINGDOM

TO THE TEACHER.—The classification of plants belongs properly to the study of botany, and this lesson need extend only far enough to teach the use and the method of classifying knowledge of plants.

1. What distinguishes this kingdom from the other two?

2. Since a classification is a scheme to show relationships, or similarities, suggest a basis for classifying plants for study. Consider size, shape, color, locality, climate, organs, uses, etc.

3. Mention all the organs of plants that you have studied and the special work done by each.

4. Which organs work for the growth of the plant? These are often called *vegetative organs*.

5. Which organs work for the reproduction of the plant? These are called the *reproductive organs*. Every plant has both these sets of organs in some form.

6. In what two ways do plants increase in size? Examine and compare a corn stock and the trunk of a young tree. Mention other examples of each kind of growth.

7. Which plants are inside growers? These are called *endogens*. Which are outside growers? These are called *exogens*. Make a list of each kind.

8. Do you discover other resemblances among members of either of these classes of plants? Consider leaves, stems, seeds, roots, etc.

9. Name plants that bear flowers; name others that do not. Compare these two classes as to number, size, and organs.

10. How is each class perpetuated? Samples of both kinds of plants should be studied under natural conditions.

11. Why is seed developing made so important in classifying plants? There are over one hundred thousand kinds of seed-bearing plants.

12. The two great subkingdoms of plants, the *seed-bearing* and the *spore-bearing* plants, are each divided further according to the peculiarities of their productive organs. Which seeds have a covering and which have none? This divides the seed-bearing plants into two large classes.

LESSON IV

THE MINERAL KINGDOM

1. What are the principal characteristics of minerals? Review previous work on minerals, especially Lesson 38, Grade 5, and Lesson 37, Grade 6.

2. On what bases may minerals be classified for useful purposes? Consider shape, color, size, formation, composition, uses, etc.

3. Tell what you know of the formation of rocks.

4. Mention rocks that give evidence of the action of water in their formation. Examine the samples in the school cabinet and secure others during field trips, etc.

5. Explain why such rocks are found usually in layers.

They are called *sedimentary* or *stratified* rocks. Where are such rocks now being formed?

6. Describe the different kinds of *sandstones* and *mudstones*, and explain their formation, ingredients, and uses.

7. Do you know of stones that are made up of larger particles than those of the shales and the sandstones? Describe *conglomerate*, or gravel stone. Infer its formation.

8. What stones show the action of fire? Which were once melted? Which seem to have been highly heated and crystallized by fire? These are called *igneous* rocks.

9. Name and describe the different *volcanic* rocks that you have seen, and such other stones as show the action of fire.

10. How was water used in forming *stalagmites* and *stalactites?* (See Lesson 38, Grade 6.)

11. Are the shells of sea animals properly classed in the animal kingdom? How and from what are they formed?

12. Make a diagram illustrating and classifying stones upon the basis of how they were formed, and let it include all the stones with which you are familiar.

LESSON V

THE MINERAL KINGDOM (Continued)

1. Are all stones composed of the same materials? Give a reason for your answer.

Experiment 1.—Test the hardness of the stones in the school cabinet by trying to scratch them with the point of a strong steel knife blade. Those that are too hard for the knife to scratch, strike together. If the blow produces an odor similar to that of burnt powder, they are probably *silicates*.

2. Mention all the silicates that you are acquainted with. What proportion of the stones in the school cabinet are of this class?

3. For what are stones of this class useful?

Experiment 2.—Put fragments of stones into strong vinegar or dilute acid. An effervescence denotes limestone, or *calcareous* rock. Also heat fragments very hot, and after cooling, wet them. If they turn white in the flame, and effervesce and dissolve when wet, they are probably limestone. Each experiment drives off carbon dioxide from the limestone.

4. Name and describe the various kinds of limestones. (Recall Lessons 39 and 40, Grade 6, on limestones.) A large portion of the earth's surface is composed of limestones.

5. Visit and describe a lime kiln.

Experiment 3.—Heat some very soft stones and moisten them afterward. When *gypsum*, or plaster stone, is heated in a kiln, it gives off steam and the stone is reduced to a white powder called plaster of Paris.

6. Why is it so called? How is it used? For what is it used?

Note.—*Selenite* is a crystalline form of gypsum, often as transparent as glass and sometimes found in very large crystals.

7. Test a piece of slate for hardness, with acids and with the flame. Examine its texture and formation.

8. Slate, shale, and such fine-grained stones are *clay stones*. Make a group of the clay stones found in the school cabinet.

9. What uses are made of the various clay stones? Where are such stones to be found now in the processes of formation?

10. Examine with a lens a piece of granite, and describe its structure. How many different materials do you see in it?

11. Test the hardness of the large white grains seen in the granite. See if acid affects them. These are grains of *quartz*, a silicate.

12. Another kind of material also may be seen flesh-colored or even white. This is *feldspar*. Test this with acid and for hardness. It forms clay when granite is decomposed.

13. The black shiny specks seen in granite are *mica*.

14. What do the grains of quartz form when granite decomposes? Have you ever seen dark shining specks in sand? What do you think they are?

15. Classify as best you can, according to their composition, all the minerals that you know.

16. Visit a jewelry store and learn to recognize and name the various precious stones there.

17. Describe a diamond. Tell all you can learn about the mining of diamonds, their grinding, the features that determine their commercial value, etc.

18. In like manner, find out all that you can about the ruby, emerald, opal, and other precious stones.

LESSON VI

THE SCHOOL GARDEN

1. Put the garden in order after the probable neglect of the summer's vacation.

2. Study the results of the neglect. What difference would good care have made?

3. What things must be done now to put the garden in the best possible condition? Give a reason for each.

4. Collect whatever fall crops there may be and make proper use of them.

THE SCHOOL BANK

Made by students in the manual-training department of the Utah State Normal Training School.

Note.—If the school garden is large enough, the crops may be sold and the proceeds used for the good of the school. Committees of students may be formed to dispose of the crops and to care for and expend the money for books, pictures, flags, or other useful things.

The Utah State Normal Training School of Salt Lake City has a garden of about six acres, the students selling the products and depositing the proceeds in the school bank illustrated on the opposite page. The bank is conducted in the usual way and checks made out in payment of the running expenses of the garden and for other purposes.

5. Compare and record results of experiments, make illustrative drawings, and mount, or otherwise preserve, specimens for future use.

6. What crops in your vicinity are harvested? Describe the processes attending the harvesting of the various crops. Explain the machinery used and the help that it gives.

7. Visit the county fair and study and report upon the garden and farm products exhibited. If possible, exhibit school garden products there.

8. What suggestions can you get from the fair for next year's work in the school garden?

9. What plants need special care to pass the winter safely? Bring into the house all plants that need such protection.

10. What can be done this fall in the soil to make its condition better in the spring?

11. Do necessary fall pruning; set out bulbs for spring flowers; mulch beds of tender plants; cover or wrap tender shrubs with straw and burlap, and clean up and prepare for winter.

12. Plan experiments and garden work for spring.

13. Summarize and record what you have learned from the garden work and from plant studies and experiments. Sup-

plement your notes with drawings illustrating plants and experiments, and changes in the appearance of the landscape due to changes in plants.

14. Study bulletins from your State Agricultural College and from the Agricultural Department at Washington, D.C., to learn what investigations they are making and how and why they conduct experiments, and report occasionally to the class.

LESSON VII

FRUITS—THEIR USES

1. Procure for study samples of as many kinds of fruits as possible, both native and imported. Pictures of fruits with the branches of trees bearing them will aid in getting clear ideas of fruits. (See cut, p. 138, Book I.)

2. Review previous work done on fruits. (See Lessons 7–12, Grade 3.)

3. Visit orchards, gardens, fruit markets, etc., and converse with dealers and raisers of fruits. Read bulletins of agricultural colleges, magazine articles, etc., and learn all that you can about fruits.

4. Make a list of all fruits found in the fall; another of fruits found in the winter; another of spring fruits; and another of summer fruits. When do we have the greatest variety of fruits? Why?

5. Which of our fruits ripen early? Which ripen late? Why is it a wise provision that all fruits do not get ripe at the same time? Show how plants, animals, and man are benefited by the arrangement as it is.

6. What is a fruit? What is its use to the plant bearing

it? Consider the definition of the green grocer, and of the botanist.

7. What fruits grow in your locality? Tell what you know of the trees on which they grow, the care that they need, etc.

8. Trace the growth of any familiar fruit from the bud to the ripe fruit, describing each organ and its function.

9. Notice the position of different fruits in their respective plants and infer a reason why some are hidden in foliage and others are exposed.

10. What fruits are raised for man's food? Which need to be cooked? Which are eaten raw? What useful fruits grow wild?

11. What drinks are made from fruits? Tell how to make lemonade, sherbet, cider, wine, vinegar, alcohol, etc., from fruits.

12. What fruits are used for flavoring? for condiments? for medicine? Are any used for perfume?

13. Tell what you know about the preparation of fruits for use and for market. Visit a canning factory and describe the processes used in canning fruits so that they will keep a long time. Give a reason for each process.

14. Tell how to make preserves, jam, jelly, etc., from fruits.

15. How are fruits dried? Inspect a fruit evaporator and tell how it aids in drying fruit. Dry a few samples of fruits, weighing before and after drying, and find out the amount of moisture lost in drying the various samples.

16. What fruits do we feed to domestic animals?

17. What wild animals eat fruits? What service do some of them give the plant in return for its fruit?

18. Tell how and where the following fruits grow: apple, pear, peach, cherry, orange, pineapple, banana, quince, raspberry, strawberry, tomato.

LESSON VIII

FRUITS—CHARACTERISTICS

1. Size

1. Arrange the samples of fruits according to size. Make a list of the fruits that you know, arranging them in the order of size. Which are classified on the market as "small fruits"?

2. Find a purpose in the various sizes of fruits. Consider in each case the size of the plant; the position on the plant; the number of seeds in the fruit and on the plant; the dangers to the fruit; the means of distributing the seeds, etc.

3. Compare, for example, the squash and the cherry, and show why each should have the size that nature gave it. What would be the result if they were to exchange places?

4. Do fruits of the same kind always have the same size? What influences the size of fruits of the same kind, and even on the same plant?

5. Do birds choose the largest or the smallest cherries? Why? Why do some oranges cost twice as much per dozen as do others?

6. What conditions and treatment aid in making the fruit large and well-flavored? What conditions produce small and poor fruit?

2. Shape

7. What is the most common shape of fruits? Why is the sphere the most compact form? Why is it the strongest and safest form for fruits? Compare it with a cube, as a form for fruits. Why does the sphere offer the greatest possible surface to the sunshine? How does it aid better than other forms in scattering the seeds?

8. Compare other forms for fruits and show why the sphere is the best for most fruits.

9. Why is an egg spherical? Why is the human skull similar to the egg in shape?

10. What fruits are cylindrical in form? Why are they suited to this form?

11. Which fruits are disk-shaped? Which are long and flat? Show a reason, as far as you can, for various shapes in fruits.

12. Draw fruits, illustrating their different forms.

3. Odor and Taste

13. What fruits can you tell by their odor? Test for yourself, and find out. Which plants have a very strong odor?

14. Of what value is odor to plants? Tell what you know of the acuteness of the sense of smell in different animals and how odor may attract some of them and thus secure the distribution of the seeds.

15. How many fruits can you distinguish by their taste?

16. See if you can distinguish varieties of apples by the taste.

17. Of what value to the plant is its flavor?

18. At what stage in the development of most fruits do odor and taste reach their greatest perfection? Infer a reason for this.

19. What is generally true of the odor and the taste of unripe fruit? Why? Is this a wise provision?

20. How may the odor and the flavor of fruits be improved?

21. Describe the odors and the flavors of different fruits. Which are sweet? sour? bitter? pungent? astringent?

22. Does color in any case take the place of odor? Compare the odor of bright- and of dull-colored fruits.

4. Color

23. Mention the different colors found on fruits. Which color seems to be the most common?

24. Does the position of the fruit influence the color? Why?

25. What is the color of most unripe fruit? When does the color generally reach its greatest brilliancy? What is the condition of the seeds at that time?

26. Of what use to the plant is the color of its fruits? Give proofs. What wild animals aid in scattering the seeds of fruits?

27. Of what value is the color of fruit to man? Which sell the better, fruits that are highly-colored and bright, or the dull, pale ones?

28. Which side of the fruit usually has the brighter color? Why?

29. Paint groups of fruits, attending to color effects.

LESSON IX

FRUITS—CLASSIFICATIONS

1. Cut open and examine the structure of various kinds of fruits. What are the principal parts of fleshy fruits?

2. Compare the coverings of the different samples. Which are thick, hard, and bony? Why do they need such a covering? Consider where they grow and the dangers that they meet, especially in the wild state.

3. What fruit coverings are thin, tough, and shiny?

4. Which are fuzzy? Which are soft and delicate? Show how the different coverings meet the needs of the fruits.

5. Examine the flesh or the pulp of different fruits just within the skin. Why are some coarse, solid, and insipid, while others are soft, juicy, and delicious? Which have much and which have little or no pulp? Infer reasons for these differences, considering especially the means depended upon for getting the seeds distributed.

6. Which seeds are protected by a strong, stony case within the pulp? Which are surrounded by a thin, tough, fibrous core? Which have no such covering, but mingle with the juicy pulp?

7. Find a purpose in each arrangement of seed. Consider the position of the fruit; the plant bearing it; the number of seeds each contains, the dangers it meets, and how it gets its seeds scattered.

8. Which is wiser, for a plant to spend strength, as does the peach, in surrounding each seed with a strong, bony covering that is a very secure protection, or in making a multi-

tude of seeds, as does the tomato, so that at least one out of the lot may escape destruction and find a place to grow?

9. Group together fruits that seem to be constructed upon the same general plan, or arrangement of parts.

The following are the principal groups of our common fleshy fruits:

I. The *gourd* family has—

(*a*) rind, thick, hard, and often brittle, generally of a dull color.

(*b*) flesh, thick, coarse, solid, insipid—sometimes almost wanting.

(*c*) seeds, flat, numerous, within a stringy mass or core.

The fruit is generally very large and grows on vines.

II. The *pome* family has—

(*a*) skin, tough, thin, and shiny; often colored highly.

(*b*) flesh, abundant, firm, juicy, and delicious.

(*c*) seeds, small, dark, few (5 to 10), incased in a thin, tough, fibrous core.

The fruit is often large, and grows on trees.

III. The *drupe* family has—

(*a*) skin, thin, colored, smooth, or fuzzy.

(*b*) flesh, soft, very juicy, delicious.

(*c*) seed, single, and in a stony case.

The fruit in size is medium or small, and grows on trees.

IV. The *berry* family has—

(*a*) skin, smooth, thin, often tender and colored.

(*b*) flesh, very soft, juicy, and delicious.

(*c*) seeds, small, numerous, and mingled throughout the pulp.

The fruit grows on shrubs and vines, and varies greatly in size.

10. Make a list of all the fruits you know that could be classed under each of these groups.

11. Which fruits keep the longest? Which fruits perish quickly? How does their structure determine this?

12. How is each kind packed for market? Which are shipped in small cups or boxes? Which in large boxes or barrels? Which in sacks? How does the structure of the fruit influence the manner of handling it?

13. Which fruit is sold by the box? by the bushel? by the pound? by the dozen? Show the convenience of these methods of selling them.

14. Which fruits grow in the tropics? Which fruits grow in our own zone? Where do we get our best oranges? grapes? apples? peaches? bananas? pineapples?

15. Learn what you can about the ways that different fruits grow and under what conditions.

To THE TEACHER.—Each pupil may be assigned a different fruit, and report to the class all that he can find out about its nature, growth, and culture.

LESSON X

TASTING

1. Of what service to us is *taste?* How does it add to our pleasure? our safety? our knowledge? our profit?

2. Make a list of all the different flavors that you can name, and mention at least one substance illustrating each flavor.

3. Distinguish by their taste different substances, as salt, sugar, alum, tea and other leaves, apple and other fruits.

Experiment 1.—Wipe the tongue dry, and try to taste salt or sugar.

4. What must happen to a substance before we can taste it?

5. Infer how we perceive the flavors of different substances.

6. Examine your tongue in a mirror. Look at some one else's tongue through a lens. Describe it.

To THE TEACHER.—With the aid of any good anatomical chart or diagram showing the structure of the tongue and the arrangement of the nerves of taste, explain this special sense.

Experiment 2.—Place small portions of substances having different flavors, on different parts of the tongue, and determine where each of the more common flavors is best perceived or recognized.

7. What part of the tongue distinguishes sweet? bitter? sour? salt?

8. When the tongue is coated by disease, how does it affect our sense of taste? Infer the reason for this.

9. Can you distinguish varieties of apples or other fruits by taste alone?

10. How may we cultivate the sense of taste and make it more accurate? How may we increase its range? Of what use would this be to us?

11. How does taste influence our appetite? our health?

12. At what time of year do we most enjoy eating fruits and vegetables? When do we relish meats and fatty foods the most? Infer a reason.

13. What animals have taste? How do they indicate it?

14. Of what value is this sense to them?

15. In what ways are plants benefited by developing a taste in stems, leaves, flowers, or fruits? Is taste ever used as a protection to the plant? Why are buds often bitter, and fruits grown from them sweet?

16. Describe the different flavors of different kinds of leaves, bark, roots, and fruits, and suggest a reason for them.

17. How does the use of alcohol affect the power to taste? In what ways is this detrimental to the individual?

18. Is the use of tobacco injurious to this sense?

19. Do professional "*tea tasters*" indulge in the use of liquor or tobacco?

Note.—The finer differences in grades of tea are determined by tea tasters who, by tasting the leaves, can distinguish with great accuracy these differences.

LESSON XI

SMELLING

1. Where is the sense of smell located?

2. Is it usual, in the animal kingdom, to have the sense of smell near that of taste? Give illustrations. Infer a purpose in thus placing them together.

3. How does smell often protect us from danger? Mention other uses of this sense.

4. A person who cannot smell suffers what disadvantages?

5. Compare the sense of taste and smell.

6. How does tasting a substance affect our power to smell it immediately afterward? Why?

7. Why does a "cold in the head" impair our power to smell?

8. How do we smell?

To THE TEACHER.—With the aid of a good chart or pictures, show how the olfactory nerves are distributed over the moist lining of the nostrils where the air and whatever odors it contains must strike whenever we inhale. In this way the nerves of smell are affected by floating particles, and we perceive the different odors.

9. Do all animals have the sense of smell? Make a list of all animals you have seen that give evidence of having this sense.

10. In what animals is it much keener than in man? Infer a reason.

11. Tell what you have observed and learned concerning the keenness of the sense of smell in animals.

12. Find out if insects, worms, fishes, reptiles, and other animals that you may be acquainted with can smell.

13. What animals are aided by this sense in finding food? in selecting food? in detecting the proximity of foes? Give illustrations in each case.

14. Name all the odors that you can. Describe the odors that you cannot name.

15. How does the range of this sense compare with that of the other senses? How many colors can you name? How many kinds of sound? How many flavors? How many odors? Make a list of each and compare them as to number and importance.

16. Which of the five senses is used the most? the least? Is there any relation between their range and their usefulness?

17. How may we cultivate the sense of smell?

18. In what occupations is a keen sense of smell needed? Consider the butcher, the grocer, the cook, the chemist, the physician, etc.

LESSON XII

PRINCIPLES OF PRUNING

1. Why do orchards ever need pruning? Compare the twigs and the leaves of an unpruned tree with those of one

properly pruned. Consider their number, size, color, vigor, etc.

2. What is the effect of severe pruning upon an old neglected tree or orchard?

3. Is there any danger of overpruning? Recall the work done by the leaves and the roots of plants, and infer the balance that must be maintained between them.

4. What object, besides reducing the amount of foliage, is secured by pruning? Recall the need of plants for sunshine, and tell how this must influence pruning.

5. Is it an economical practice to cut large limbs from trees? How might such a need be avoided in most cases?

PROPER METHOD OF PRUNING

IMPROPER METHOD OF PRUNING

6. What care should be taken when cutting off large limbs? Consider the angle of the cut, its distance from the trunk, its chances to heal, the dangers of disease in the dead wood, etc.

7. How may trees be pruned to make them grow tall and slender? How may they be made to grow low, stocky, and spreading?

8. Which shape is the more convenient for cultivating an orchard with a team? Which is the more convenient for gathering the fruit? Why?

9. If the orchard is in a region where strong winds are frequent, which form is the better? Why?

10. In the arid regions, where there are three hundred days of bright sunshine a year and where "sun scald" is frequent, how should the foliage compare in density with that in humid regions, where trees are troubled with moss, mildew, and fungi, and where there is little sunshine?

11. When is the most important time in the growth of an orchard to prune with care and wisdom?

PRUNED TO AVOID SPLITTING

TRUNK LIABLE TO SPLIT

12. In pruning a small tree, how should the main branches be allowed to leave the trunk? Should the trunk be allowed

to divide into two main branches running in opposite directions? What danger will this bring to the tree when old?

13. How may prevailing winds throw trees out of balance? Can pruning remedy this? How?

14. Since pruning checks growth in one place and stimulates it in another, what will be the effect upon fruit development of cutting off terminal buds to prevent wood growth?

15. What effect upon the fruit left has thinning the fruit upon heavily laden trees? Why?

16. Under what conditions should there be root pruning?

17. May diseased roots be benefited in this way?

LESSON XIII

SUGAR

1. If possible, visit a farm where sugar cane or sugar beets are raised, and learn all you can about these crops. Also visit a sugar factory, and study the processes to be seen there.

2. Plant sugar cane and sugar beets in the school garden, and get materials for the following experiment.

Experiment 1.—Cut into small pieces a portion of a sugar beet, or some of the inner pulp of a stalk of sugar cane, and place the pieces in a cup or vessel in which they can be boiled. Add water enough to cover them, and boil for some time, skimming when necessary. The sap of the sugar-maple tree, or watermelon juice, or even water, slightly sweetened with sugar, may be used if beets or cane cannot be obtained.

3. Note the changes in the quantity, color, taste, etc., of the liquid as the boiling continues. Account for these changes.

4. When the liquid becomes a sirup, let some of it stand for a time in a cup, then pour off the top carefully and see if there is a sediment.

5. When the sirup gets thick enough to form a granular sediment, strain it through a woolen cloth.

6. Examine and describe both the liquid that passes through and the sediment that is retained in the cloth.

7. Compare the sediment with sugar. What is the difference between raw and refined sugar?

Note.—Filtering the sirup through a layer of animal charcoal, made from bones, as other charcoal is made from wood, helps to refine and whiten the sugar.

8. What other solutions, upon evaporating, will deposit crystals?

Experiment 2.—Suspend a string in a strong, hot solution of sugar, and note the crystals that form as it cools. Try solutions of salt, alum, blue vitriol, etc.

9. Name as many uses of sugar as you can.

10. What other plants contain sugar?

11. Tell what you know of the growth and the importance of the sugar industry. Where is the most sugar made?

12. What is molasses? How is it made? For what is it used?

13. From what is maple sugar made? How is it made?

14. How are the cubes of loaf sugar made? How is pulverized sugar made?

15. Describe the differences between different kinds of sugar, as beet sugar, cane sugar, maple sugar, etc.

EIGHTH GRADE—WINTER WORK

LESSON XIV

INERTIA AND MOMENTUM

Experiment 1.—Tie a stone the size of a man's fist in the middle of a piece of common wrapping twine, and suspend it from any convenient support. From the lower end of the string pull until the string breaks.

1. How can you make the string break above the stone?

2. How can you make it break below the stone? Explain.

3. Is the full force of a sudden jerk transmitted to the upper part of the string? Why?

Experiment 2.—Balance a visiting card in a horizontal position upon the end of a finger, and place a small coin upon it directly above the finger. Give the card a sharp horizontal snap, and note the tendency of the coin.

4. Think of many illustrations of this tendency of matter at rest to remain at rest.

5. Wherein is this law of use to man? Can you think of circumstances under which it is harmful?

Experiment 3.—Suspend by a strong cord some heavy weight—a coal scuttle full of coal will do. Attach a slender thread to the weight, and gently pull upon it at regular intervals until the weight begins to swing as a pendulum. When it is swinging over a large arc, try to stop it with the thread as quickly as possible without breaking the thread.

6. Why did not the weight begin to swing with the first pull upon the thread? Why was not one pull sufficient to stop it?

7. Did you ever stop a swiftly pitched baseball? What was the tendency of the moving ball?

8. What is the tendency of matter in motion? Prove this by many examples from your own observation.

9. Why are loaded wagons, trains, boats, etc., so slow and difficult to set in motion? Why are they so hard to stop quickly?

10. What relation do you see between the weight or the mass of a body and the force required to set it in motion or to stop it? Give examples to illustrate this relation.

11. What relation is there between the force used and the speed of the body? Give illustrations.

12. What relation is there between the time and the force required to start or to stop a given mass? Will a gentle force start or stop a body as quickly as a strong force will? Illustrate this by examples.

13. Compare these laws of compensation with those of the lever, inclined plane, pulley, etc.

Experiment 4.—Roll with the same force a heavy ball on the ground, on the floor, and on smooth ice. Compare and account for the distance it goes in each case.

14. What brings the ball to rest in each case? If there were no friction nor forces to bring the ball to rest, what would be the result?

15. In which case is the ball's path the most nearly a straight line? What caused it to change its direction at all?

16. Would its direction change if it encountered no con-

trary force? What is the tendency as to direction of a body in motion?

17. How does man make use of this law of motion? Give many illustrations of it.

18. Explain the use of the hammer in driving a nail. Upon what two things does the force of the blow depend?

19. Apply the foregoing principles to the use of the fly wheel in machinery.

20. What law of motion makes good marksmanship possible?

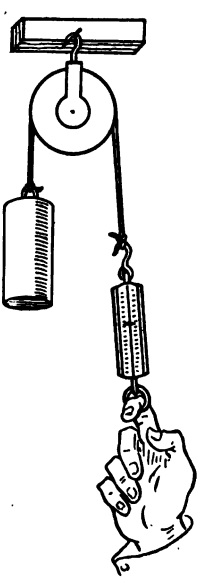
21. Explain the action of the laws of motion as applied in the following: the destruction of a railroad collision; the fall on leaving a moving street car; the flying of mud from a fast-moving carriage wheel; the gunpowder behind a cannon ball; the striking force compared with the amount of powder used and with the size of the ball.

22. Think of other applications of the laws of motion.

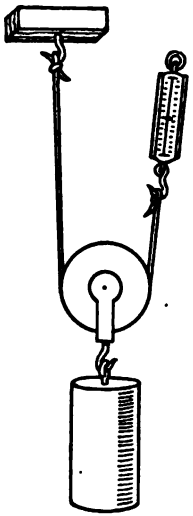
LESSON XV

THE PULLEY AND ITS USES

Experiment 1.—Procure at a hardware store, or make in the manual-training room, a number of separate pulleys and small blocks containing three or four pulleys each. Fasten a single pulley to some convenient support, and pass over it a cord having a given weight fastened to one end of it, and a spring balance to the other. Compare the weight with the force measured by the spring balance in sustaining or raising it.



EXPERIMENT 1



EXPERIMENT 2

1. Suppose the weight to be six pounds, what must be the power to balance it?

2. In what direction does the power act? the weight?

3. What advantage is gained by the use of a fixed pulley? Give examples where you have seen fixed pulleys used.

Experiment 2. — Attach a weight to a movable pulley, as shown in the cut, and note the amount of power required to sustain it.

4. What part of the weight is sustained by the hook? by the spring balance?

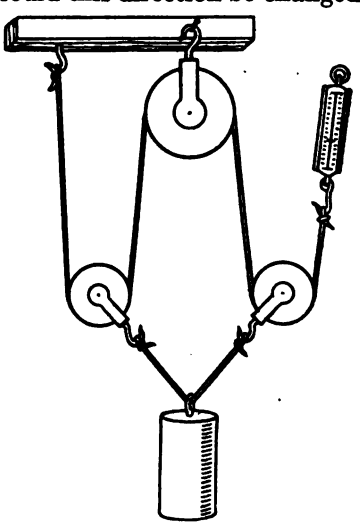
5. In what direction does the power act? How could this direction be changed by using a fixed pulley?

6. Through how much space must the power pass in raising the weight one foot when one movable pulley is used? when one fixed pulley is used?

Experiment 3. — Arrange one fixed and two movable pulleys supporting a weight, as shown in the cut.

7. What part of the weight does each section of the string support?

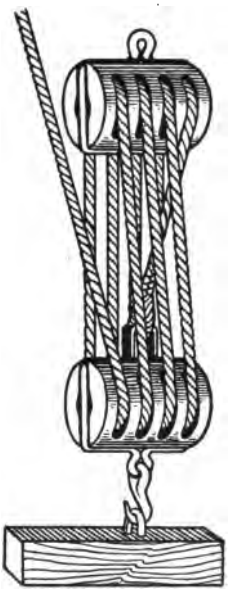
8. What portion of the



EXPERIMENT 3

weight is supported by the hook? by the fixed pulley? by the balance?

9. To raise the weight one foot, how far must the power move? What is gained by using two movable pulleys? What is lost? How do the loss and the gain compare?



10. Recall the loss and the gain in using different forms of the lever and the inclined plane.

11. If another fixed pulley were added, what would be the effect? If another movable pulley were added, what advantage would be gained?

12. If all the fixed pulleys are placed in a single block, and all the movable ones in another, and the string is made to pass around them all, what advantage is gained?

13. Tell where you have seen the block or tackle used.

14. Upon what does the power gained in using a tackle depend? State a rule for computing it.

LESSON XVI

THE ART OF PRINTING

1. Of what value is printing to the human family? Compare the present condition of the world with former times as influenced by printing.

2. Give an account of the invention of printing. (You can get information upon this subject from any good encyclopedia.)

3. Compare the prices of books now with their cost before printing was invented, when all books were written or engraved.

4. Visit a printing establishment, and observe all the processes of this wonderful industry.

5. Describe how type is set by hand and by machine. Examine samples of type. Describe a typesetting machine.

6. How is the type placed in "forms" to make pages?

7. How is it covered with ink and made to print? Describe a news press; a book press; a job press; and how each does its work.

8. How are newspapers counted, folded, and distributed?

9. How are the sheets of a book folded, sewed, and bound into volumes?

10. What wages do printers get?

To THE TEACHER.—Since most pupils will have to follow some industrial occupation for a livelihood, and since we are all dependent upon the world's workers, the class should visit frequently such industrial establishments as allow visitors, and as are conveniently located, in order that they may become acquainted with the activities, processes, and products of such places. If you cannot visit a printing office, choose some other place where workmen are employed, and adapt the lesson accordingly.

LESSON XVII

THE STUDY OF LIGHT

1. Why cannot one see objects in the dark?

2. Does light go from the eye to the objects seen, or *vice versa?*

3. What bodies give forth light? They are called *luminous bodies*. Those that do not give forth light are *non-luminous bodies*.

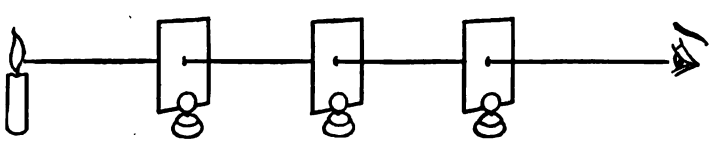
4. In what directions does light travel from a luminous body? Give illustrations to prove it. Compare with heat and with sound.

5. How does distance from the source of light affect the strength or intensity of light? Explain this law. Recall the effect of distance in the case of heat and sound. (See Lesson 3, Grade 7.)

6. How is the intensity of light affected by the slant of its rays as they fall upon a given surface? How do we hold a book when reading by a dim light? Why?

7. What part of the day is brightest? Why? What season of the year gives us the most light from the sun? Why?

Experiment 1.—Make a small hole near the center of each of three cards, and set them in card holders at convenient distances apart,



in such position that the light of a candle may be seen through all of them at once. Carefully pass a thread through the holes and stretch it.

8. What must be the position of the holes when the light is seen through all of them? Give other proofs that light travels in straight lines. What uses are made of this law of light?

9. Why cannot one see around a corner?

10. Account for shadows and for their sizes and shapes as related to this law of light.

Experiment 2.—Place a mirror in the sunshine, and study the reflected beam. A dark room with a single beam entering it should be used, if possible.

11. Notice the angle of the beam as it strikes and as it leaves the mirror. Move the mirror, and note the effect upon the reflected beam, until a relation is discovered between the angle of *incidence* and the angle of *reflection.*

12. Substitute a white paper for the mirror. Explain the different effects. Which throws the more light into the room? Which reflects the more light? Why?

13. Substitute a black surface for the beam to strike. Compare and explain the results.

14. Under which condition is the more light *reflected? diffused? absorbed?*

15. What practical uses are made of these properties of light?

16. Should a poorly lighted room have light or dark wall paper?

17. Why does a photographer use a black cloth over his camera?

18. Why do travelers over snow get "snow-blind"?

19. How does light enter windows on the opposite side of the house from the sun, and fill the whole house?

Note.—Light is not perceived until it strikes an uneven surface and is diffused. Each surface that it strikes helps to scatter the rays until space is filled with them.

LESSON XVIII

THE STUDY OF LIGHT (Continued)

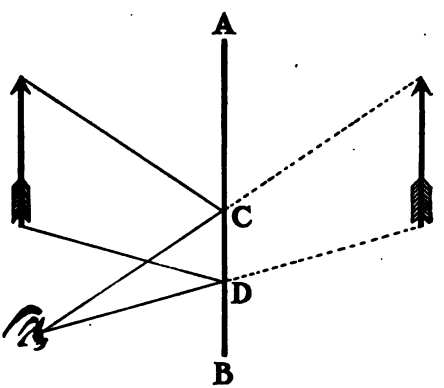
1. Why do we see ourselves in a looking-glass, but not in other kinds of surfaces?

2. What gives us the notion of the direction from us of the things that we see?

3. How do we judge their distance? What effect has distance upon the apparent size of objects?

4. Why does the image of an object before a mirror appear to be behind it? How far behind the mirror does the object seem to be?

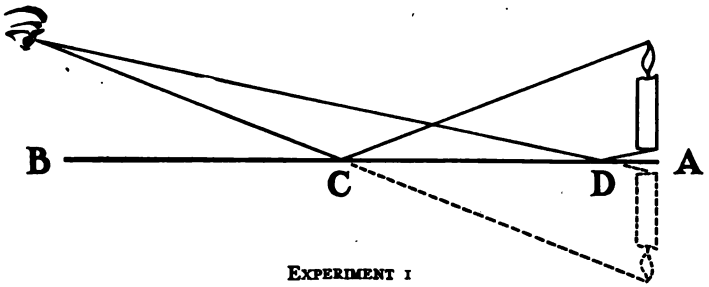
Note.—Objects are seen in the direction that the light from them enters the eye; if the direction of the light is changed by the mirror, the direction of the objects will be changed to correspond.



5. Suppose *AB* to be a plane mirror; trace the light from the head of an arrow in front of it that would reach the eye below. Where must the image of the arrow head appear to that eye? Where would the image of the other end appear to be? What part of the mirror is used in seeing the arrow?

6. If the position of the eye or of the object were changed, how would it affect the portion of the mirror used?

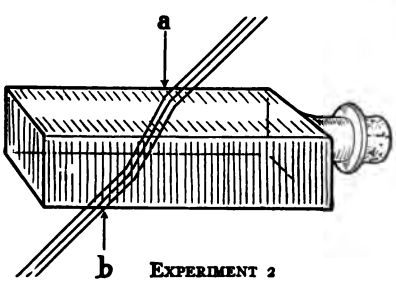
Experiment 1.—Place a candle at the edge of a horizontal mirror, and explain why its image is inverted.



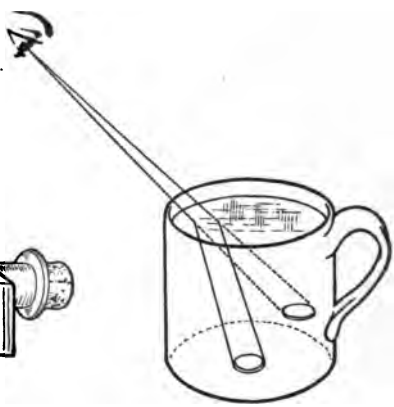
EXPERIMENT 1

7. Explain in a similar way why your right hand makes the image of the left hand in a vertical mirror.

Experiment 2.—Fill a bottle having a square base with clear water and lay it horizontally where a single beam of sunshine will strike it at an angle and pass through it. The room should be dark.



EXPERIMENT 2



EXPERIMENT 3

8. Is the light bent toward or from a perpendicular (*a*) to the surface where it enters? Where it leaves (*b*)?

Experiment 3. — Drop a penny in the bottom of a cup, and stand in such a position that the rim just hides the penny from view. Now fill the cup with water, and explain why you can see the penny.

9. Does the light that reaches the eye from the penny bend toward or from a perpendicular erected to the surface of the water at the point where it passes out?

10. In what direction is light bent upon entering obliquely a denser medium? a rarer medium?

11. Why does a straight stick or pencil seem bent where it enters the surface of water obliquely?

12. Do Indians, in shooting fish, aim over or under where the fish seem to be?

13. Does clear water look to be as deep as it really is?

14. Draw a figure representing the light of the sun at sunrise entering the layer of atmosphere and reaching us. Will it be bent? If so, where will the sun appear to be from where it really is?

Note.—Air is denser than empty space beyond it.

LESSON XIX

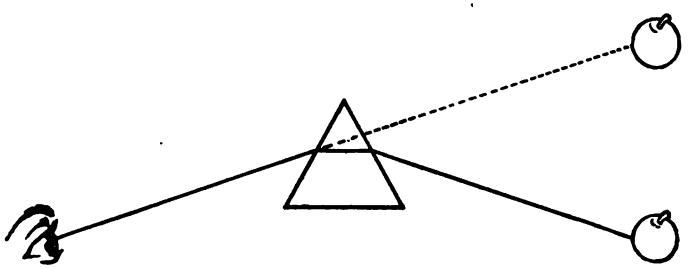
OPTICAL INSTRUMENTS

1. Mention as many kinds of instruments as you can that are used to aid us in seeing, or in making pictures with rays of light. Tell as best you can how each is made and used.

2. Describe a "sunglass." How does it "draw" the sun's heat? In what position is it the hottest? Is the light the most intense where the heat is the greatest? Could a sunglass be made of a piece of ice? What is the shape of a sunglass? Does it magnify? How might a fire be made with a piece of ice?

Experiment 1.—Look at an object through a prism. Make a diagram showing how the light from the object goes through the prism

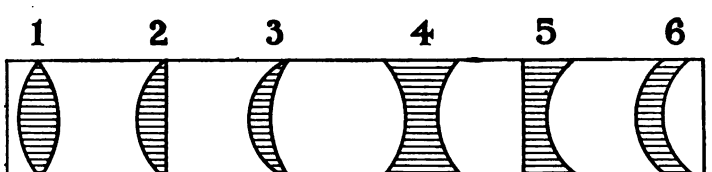
and is bent; how it enters the eye, and how it seems to change the position of the object. Explain each step by drawing a perpendicular



wherever the light changes medium and by applying the law of refraction of light. (See question 10, previous lesson.)

3. Describe the shape of a pocket lens or of a magnifying glass. In what part is it the thickest? the thinnest? Do the edges in any way resemble the edge of a prism?

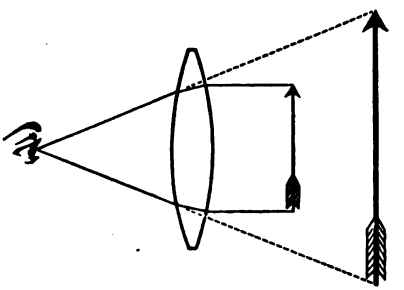
Note.—Glass lenses are made in six general forms, and named according to their forms. They may be considered as being formed as follows:



SIX GENERAL FORMS OF GLASS LENSES

1. Double convex by the intersection of two spheres.
2. Plano-convex by the intersection of a plane and a sphere.
3. Concavo-convex by the intersection of a small sphere by a large sphere.
4. Double concave by the intersection of a cylinder by two spheres.
5. Plano-concave by the intersection of a cylinder by plane and sphere.
6. Concavo-convex by the intersection of a cylinder by two spheres.

4. From the drawing explain how the rays of light from an object near a double convex lens will pass through the lens and magnify the object. Erect a perpendicular wherever the ray changes medium, and apply the law of refraction of light.



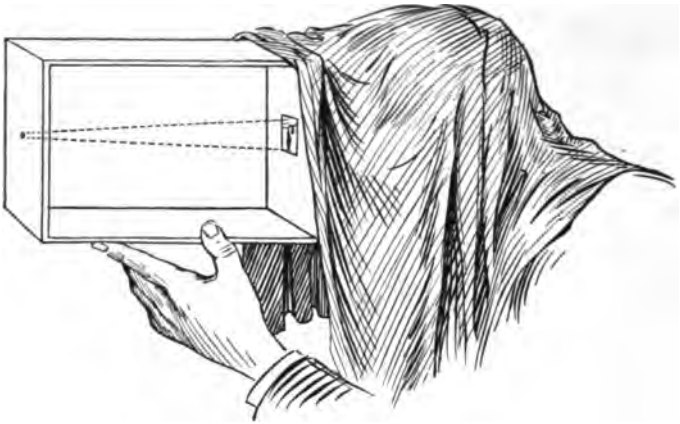
Note.—The perpendicular to any point on a curved surface is a line drawn from the center of the curve through that point—a radius extended.

5. Experiment with spectacles, opera glasses, lenses, etc., and discover facts concerning their use. Are objects seen through them at different distances equally distinct? Do all lenses magnify to the same degree? What shape magnifies the most? Do any lenses make things look smaller? How may two lenses be placed to increase their power? Look through the wrong end of the opera glasses. Explain as many of these phenomena as you can.

Experiment 2.—Make a pinhole camera as follows (see cut, next page): Take a box 8 × 8 × 12 inches, cut a hole 3 × 3 inches in one end, cover it with a piece of glass, and tack a piece of black cloth around the top and the two sides at that end. Make a small round hole at the other end and cover with a piece of tin foil containing a large pinhole. Place your head under the cloth to cut off the light, as a photographer does in examining an image in his camera, and you will see on the glass images of objects in front of the hole in the tin foil. The objects should be in a bright light to be seen well.

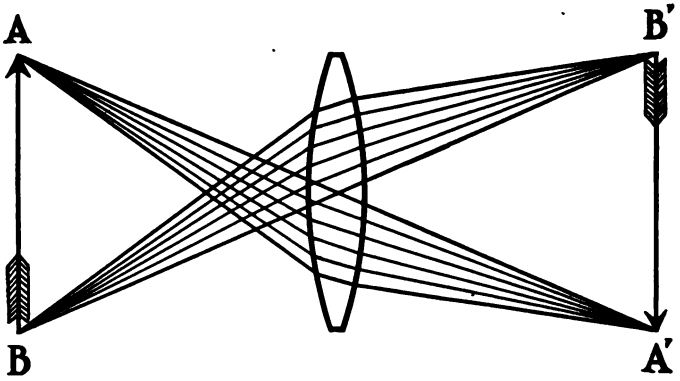
6. Explain the formation of such images. Why are they inverted?

Note.—An image is formed generally when the rays of light from an object, or scene, are made to come together in the same plane.



A PINHOLE CAMERA

7. Follow the rays of light from an object through a double convex lens, and explain why and where its image will be formed.



8. Why are such images inverted? Where do the rays from the two ends respectively come to a focus? Where do

they pass through the lens? The light from intermediate points may be traced also.

9. Describe a kodak; a photographer's camera. How are images formed in them?

10. How are such images fixed and a negative made?

Note.—The sun's rays contain light and heat and chemical energy, all of which are acted upon similarly by lenses. The images of the chemical rays acts upon a chemical compound that covers the negative, changing it wherever it strikes, and forming an image of the object. This is "fixed" in the dark room by the use of still other chemicals, so that light will no longer affect it. The negative thus formed may be used over "sensitive" paper in the sunlight, and as many photographs made as desired. The sensitive paper is treated similarly to the negative after receiving the image through the negative.

11. Describe a compound microscope and its uses.

12. Tell what you know about a telescope. Give the history of its invention.

13. Why are objects seen in cheap mirrors, or through cheap glass windows, often misshapen and grotesque?

14. How are pictures thrown upon a screen? Describe the structure of a stereopticon.

LESSON XX

THE EYE—SEEING

1. Mention the dangers and the disadvantages due to blindness.

2. Examine the eyes of different animals, as quadrupeds, birds, fishes, insects, etc. Note their size, position, parts, number, and ability to see in water or at night.

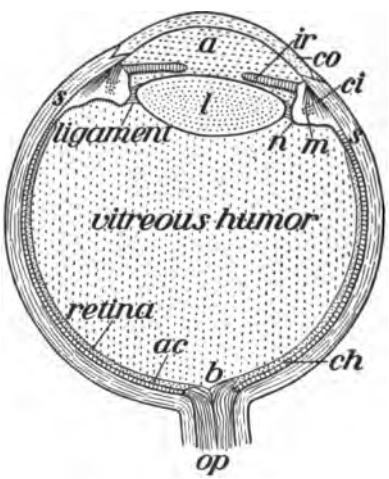
3. Study animals that have no eyes, as the earthworm,

and learn what substitutes they have, or how they get along without vision.

4. Why do we need two eyes? Close one eye, and note the relative accuracy of vision with but one.

Experiment 1.—With your face toward the light, read awhile from a printed page, which will then be in a shadow. Reverse your position, and resume your reading with your back to the light and the page illuminated.

5. What is the effect upon the eyes? What is the difference in ease and clearness of vision? Explain.



LOWER HALF OF THE LEFT EYEBALL

a, Watery humor; *b*, entrance of the nerve of sight, *op*; *ci*, muscles to change the lens for near sight; *ir*, iris; *co*, cornea; *l*, lens; *ch*, black membrane.

6. If the light that enters the eyes is too strong for them, what is the effect? If too weak?

7. Describe the visible parts of the human eye and their movements. Consider the eyebrows, eyelids, eyeballs, pupils, etc., and the use of each.

8. Under what circumstances and for what purposes do we wink? move the eyeballs? raise the eyebrows? increase or decrease the size of the pupil of the eye?

9. Which motions of these parts are under the control of the will? Which are made unconsciously? Show the wisdom in this.

10. How do the eyes act when we go from a strong light

into a dark room? from a dark room into a strong light? Account for this. How does the eye adjust itself to such extremes?

11. Why can cats, owls, horses, and other animals see in the dark better than we can? Study their eyes, and find out wherein they differ from ours.

12. Why is a fly so difficult to catch? Examine the eye of a common house fly with a good lens.

13. How is the fish adapted to see in the water?

14. What is the use of window blinds? lamp shades? eye shades?

15. How are our eyes kept moist? What becomes of the liquid used in keeping them moist?

Note.—An organ called the *lachrymal gland* above and near the outer corner of the eye secretes the tears; after serving their purpose in moistening the eyeball, the tears pass down the *lachrymal duct* into the nostrils, from the inner corner of the eye.

16. Why is the eye so sensitive? How do the eyelashes protect it from dust, etc.?

17. What keeps the perspiration of the brow from running into the eye? What harm would it do?

18. Suggest a good way of removing from the eye foreign particles of dirt.

Note.—Drawing the upper lid far over the lower lid, and at the same time blowing violently the nostril on that side, will often remove a particle from the eye. If the particle adheres to the inner side of the upper lid, the lower eyelashes may wipe it off. Blowing the nostril on that side probably draws the excessive tears to the inner corner of the eye by suction created in the lachrymal duct. Here it is easily removed. A moistened flaxseed often will adhere to a rough particle in the eye and cover it so that it ceases to irritate the eyeball until both work their way out at the inner corner of the eye.

LESSON XXI

A SHOE FACTORY

1. Visit a shoe factory, and study the processes used in the manufacture of different kinds of shoes.

2. Get samples of different kinds of leather; learn their names, and for what each kind is used.

3. Learn to tell "split" leather, and to judge of quality in leather.

4. Name the different parts of the shoe. Tell what kind of leather is used for each part.

5. Describe how the leather is cut for each part and for shoes of various styles and sizes.

6. What machines are used in this work?

7. How are the "uppers" put together?

8. How are the soles attached?

9. Which are the better, "sewed" or "pegged" shoes?

10. Describe the machines that do this work.

11. To what extent is the work of making a shoe divided? Show the advantage of the division of labor seen in a great shoe factory.

12. Where are there great shoe factories in our country?

13. What can you say of the use, value, and extent of this industry?

LESSON XXII

USES OF ELECTRICITY

1. Describe the different kinds of electric lights that you have seen.

2. Mention as many different uses of the electric light as you can, and show its superiority over other artificial lights.

3. How is the light turned on and off in each case? Examine the parts of a lamp, or switch, and notice the mechanism of the parts and how they work in controlling the electric current.

4. How are electric signs made to be intermittent?

5. Where have you seen electricity made to produce heat? Describe an electric flatiron; an electric stove, or heater.

6. Have you ever seen a tree that has been struck by lightning? Did it show any signs of fire?

7. Have you ever heard of houses, barns, oil tanks, etc., having been set on fire by lightning?

8. How is electricity used in blasting?

9. What things are moved by electricity? What kinds of work are now done by electricity?

10. In which of these three ways is it the most useful to man, — in giving light, heat, or motion?

11. How is electroplating done? What can you say of the importance of this industry?

12. In what ways is electricity dangerous? Mention accidents that you have heard of from this cause, and how they happened.

13. What precautions are taken to prevent accidents from electricity?

14. What is a "live" wire? How may it be handled safely?

15. Tell what you know about the history of electricity.

16. Mention men who have made important electrical inventions.

17. Mention all the uses of electricity that you can think of.

18. Visit a power house, telegraph office, telephone exchange, and study all machinery and devices that you can where electricity is manufactured and used, and report to the class what you learn.

LESSON XXIII

LAWS OF ELECTRICITY

1. Review the work done with the magnet in Lesson 30, Grade 6.

2. What is a magnet? How many kinds of magnetism are there? How do they behave toward each other?

3. How may magnets be made? What material generally is used for magnets? Will brass or iron make good permanent magnets?

Experiment 1.—Test the action of a magnet upon bits of steel, iron, brass, silver, wood, and other things. Make a list of substances which it attracts, and another of things which it will not attract.

4. For what are magnets used? Test the distance through which they will exert their power. See if they will attract through paper, glass, etc.

Note.—In the following experiments notice the similarity in the actions of electricity and what you know of magnetism.

Experiment 2.—Procure a ball of the pith of a sunflower stem or an elder stock, and suspend it by a silk cord. Rub a glass rod with a silk handkerchief and bring it near the pith ball.

5. Why is it at first attracted? Why is it then repelled? Touch the ball with the finger, and try the experiment again. Explain what happens.

Experiment 3.—Rub a bar of sealing wax, or a rubber comb, with a piece of dry flannel, and note the action of the pith ball when approached by either of them.

Experiment 4.—Rub, as before, the glass and the wax, and place one on each side of the pith ball and explain what happens.

6. Would the results be the same if two glass rods or two bars of sealing wax were used instead of one of each?

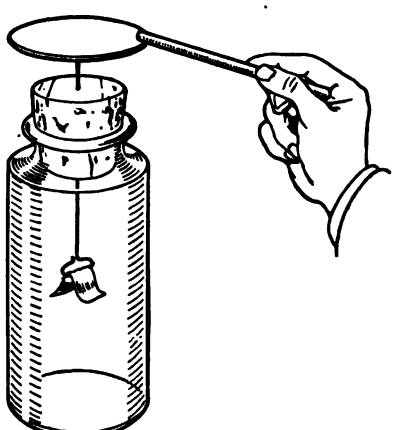
Experiment 5.—Bring each of these in turn close to a magnetic needle, and see if the electricity in them is different or alike. What kind has each?

Note.—The pith ball readily becomes charged with electricity when near a supply, but yields it up with equal ease to any near-by conductor.

7. Under what other circumstances have you seen electricity developed through friction? This kind is called *static electricity*.

8. Explain the sparks often seen in a cat's fur when she is stroked in the dark.

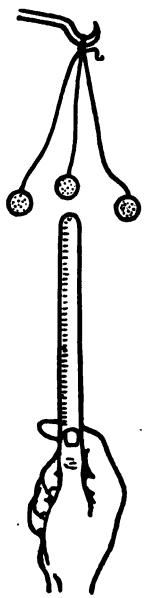
Experiment 6.—An electroscope, more sensitive, perhaps, than some magnetic needles, may be made as follows: Solder one end of a wire to a metal disk, and bend the other end to form a stirrup after passing it through a large cork. Hang in the stirrup a strip of very thin gold leaf ¼ inch wide and 1½ inches long, and place it in position within a large bottle, as shown in the cut. Bring an electrified body near the disk, and the gold leaves instantly diverge. Why?



EXPERIMENT 6

9. Present alternately the electrified glass and the wax to the electroscope, and explain its behavior.

Experiment 7.—Hang several pith balls from the same point of support, and place near them the glass rod; explain their action. Exchange the rod for the wax, and explain the changes made.



EXPERIMENT 7

Experiment 8.—Support one end of a yardstick upon a bottle and the other upon the disk of the electroscope, present an electrified glass rod to the farther end, and note the effect upon the gold leaves.

10. How did the electricity reach the leaves?

11. Repeat the experiment, using a long glass rod instead of the yardstick. Explain the difference in the effect upon the gold leaves.

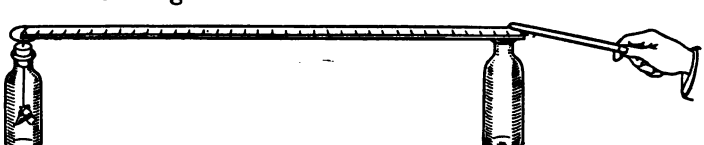
12. Mention substances that are good conductors of electricity. Mention poor conductors.

13. What is generally used to convey electricity in commerce? Why is copper wire preferred?

14. Why are glass or porcelain supports used to carry electric wires?

15. Why do electricians often wear rubber gloves and shoes?

16. Why are electric wires often covered with cotton, silk, or other coating?



EXPERIMENT 8

Experiment 9.—Fasten a piece of copper and a strip of zinc to a cross-piece of wood and suspend them in a tumbler containing dilute sul-

phuric acid. Attach a wire to each piece of metal and wrap it around a piece of soft iron. The iron becomes a magnet, and readily picks up iron filings or other magnetic things.

EXPERIMENT 9

17. Observe the contents of the tumbler. Examine the ends of the metal strips after they have been in the acid a short time.

18. What created the electricity that converted the iron into a magnet? This is called *voltaic electricity*.

LESSON XXIV

ELECTRICAL INVENTIONS

1. THE COMPASS

1. Describe a mariner's compass.

2. Tell what you can of its many uses. (See Lesson 30, Grade 6.)

Experiment.—Arrange the two ends of a wire from a battery parallel to the needle of a compass as it lies at rest, pointing northward. Complete the circuit by bringing the two ends together, and note how the current affects the needle. Open and close the circuit several times.

3. What is the effect of an electric current upon a magnetic needle?

4. Place a magnetic needle near any wire through which a current is passing, and verify the law.

5. What position does the needle always assume with respect to the direction of the current?

6. Infer why the magnetic needle commonly comes to rest pointing north and south.

Note.—It is supposed that the sun causes a current of electricity that is always flowing around the earth from east to west.

2. Lamps

1. Describe a common electric lamp. Turn the light on; turn it off. Tell how this is done.

2. How does the light compare with that of a candle? With that of a kerosene lamp?

Note.—The common electric lamp is equal to 16 candles.

3. What produces the light? How does the electricity reach the lamp? Why is the air removed from the globe?

4. Describe the electric wires of your school, and how they are placed, giving reasons for what you observe.

5. Where is the electricity made that is used at school? How does it reach the building?

6. Visit a switchboard and see how the current is turned on and off the different rooms.

7. Tell what you know of the different kinds of electric lamps. Consider how they are made; their cost; the

amount of electricity used; the intensity of their light, etc.

8. Explain the difference between an incandescent lamp and an arc light. How does each get its name?

Note.—The first arc light was invented about a century ago. A strong current of electricity was produced from a great battery of 3000 cells. The wires from this immense battery were brought near each other, and the current of electricity passed steadily from one end to the other through the intervening air, making a most brilliant light. It also made such great heat that the ends of the wires had to be protected by carbon points so that they would not melt.

9. How is most electricity made now?

10. Describe the many uses of the electric light, and compare its convenience and efficiency with that of the old methods of illuminating public streets and buildings, private homes, factories, mines, and other places.

3. Bells

1. Mention various uses of the electric bell. Consider its great convenience and value.

2. If possible, get an electric bell and examine its parts and discover how they work. Draw a diagram showing the arrangement and the action of its parts.

3. Upon what laws of magnetism does its action depend?

4. Install an electric bell, or repair one that may be out of order, if you get an opportunity.

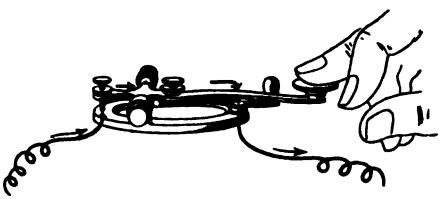
4. The Telegraph

1. Visit a telegraph office and see how messages are sent and received over the wires.

2. Tell what you can of the convenience and the economy of the telegraph.

3. Who invented the electric telegraph? Give an account of its invention and introduction into the commercial world.

4. Draw a diagram showing how a current of electricity may be caused to flow through a wire and stopped at will.



A Telegraph Key

5. Examine and describe a telegraph operator's key, and show how it serves to break or to complete the electric circuit, causing spurts of electricity of any desired length and separated by any desired interval to pass over a wire.

6. How may these broken currents of electricity be made to produce any desired combination of dots, dashes, and intervals at the other end of the wire?

7. Draw a diagram, showing how telegrams are sent.

Note.—The telegraphic alphabet invented by Morse consists of a series of dots and dashes, with intervals between the letters, and longer intervals between the words. In the first instruments these were traced on strips of paper, but now they are read generally by sound.

The Morse Alphabet

A - —	H - - - -	O - -	U - - —
B — - - -	I - -	P - - - - -	V - - - —
C - - -	J — - — -	Q - - — -	W - — —
D — - -	K — - —	R - - -	X - — - -
E -	L —	S - - -	Y - - - -
F - — -	M — —	T —	Z - - - -
G — — -	N — -		

8. Mention other useful electrical inventions or machines.

9. As you have opportunity, study and report to the class upon such electrical inventions as the following: flatiron, heater, fan, motor, dynamo, street car, telephone, etc.

EIGHTH GRADE—SPRING WORK

LESSON XXV

THE INFLUENCE OF SURFACE FORMS

1. Consult a good physical map of North America. Locate the principal mountain systems; the great highlands and arid regions; the great plains; the chief river valleys; the low coast plains, etc.

2. Describe and explain conditions in the mountain regions. What occupations do men find in the mountains? What are the chief products from these districts? Why? Are any large cities found there? Why?

3. Describe the Great Plateau. Why does it have so little rainfall? What partially supplies man's needs for rain there? Tell what you know of the great deposits of snow, the origin of many great rivers, and the work of irrigation in the Great Basin and the arid West. What are the chief occupations there? What are the chief products? Why? How are most of the cities located? Why?

4. Describe the Great Plains. What is their chief use to man? What conditions there determine largely the occupations of the people? What are their chief products? Compare the population with that of other parts of the

United States. Name and locate the principal cities, and account for their place and size as far as they are influenced by geographical conditions.

5. Tell what you can of the great river systems of North America. Consider climate, soil, products, water transportation, and the occupations of the people. What large cities are found on the great rivers? Why?

6. Tell what you can of the climate, soil, occupations, and products of the coast plains. For what are they adapted?

7. Compare and account for the size of cities on the coast, in the river valleys, on the plains, and in the mountainous regions.

8. What products are raised in the lowlands? Why?

9. In what part of the United States is the most manufacturing done? In what way have surface forms affected this industry?

10. Where are the great commercial cities? What advantages do they enjoy because of the shape of the surface near them?

11. How is climate influenced by this cause?

12. How does physiography fix the corn belt? the cotton belt? wheat belt? rice belt?

13. How has it influenced the history of our country?

14. Where would you look for mines of coal? of precious metals? Why?

15. What conditions are necessary for stock raising? Where are these conditions found?

16. What natural conditions are needed for successful farming? lumbering? manufacturing? fishing? hunting and trapping? mining? commerce? Where in our country can each set of these conditions be found?

LESSON XXVI

CHANGES IN THE EARTH'S SURFACE

1. How is erosion slowly changing the surface of the earth? Review the previous work on erosion.

2. Visit a cañon, ravine, or "wash." How was it made? Where is the earthy matter now that was taken from it?

3. Why are the mountains generally rocky? the foothills gravelly? the lowlands fine and fertile? Mention examples to show that this is true.

4. With the aid of a good relief map, tell what must have been the growth of the valley of the Mississippi; the Ganges; the Nile. Where did the soil come from in each case? What can you say of the fertility of each valley?

5. What effect has this action had upon the mountains near these valleys?

6. If mountains were never made to rise, what would be the final result of erosion upon the surface forms of the earth?

7. What other agents are changing the forms of the earth's surface? Tell what you know of the results of volcanic action upon surface forms. Name volcanic islands.

8. What proofs are there that volcanoes have done much in forming the earth's surface? Learn all you can of the great lava beds in the northwestern part of the United States; in Mexico; in South America, and in other places.

9. How have these great lava fields been crumbled into the best of soil through the wonderful forces of nature?

10. What plant first grows on rocks? Find rocks that are covered with lichens, moss, etc., and learn what changes they are slowly making in the surface of the rocks.

11. Describe how coral islands are formed. Study a piece of coral, and learn the life history of the coral polyp and how it does its work.

12. Which one of the states is built mostly upon coral?

13. Tell how each of these agents is modifying the surface of the earth; heat and cold; rain, snow, and hail; rivers, waves, tides, wind, volcanoes, glaciers, avalanches, plants, animals, and man.

LESSON XXVII

THE BOTTOM OF THE SEA

1. Describe the bottom of any lake or pond that you have seen drained. Compare it with the surface of the land in that vicinity.

2. If you have ever seen the bottom of the sea near the coast, describe the soil, plants, and animals that you may have seen. How does the sea bottom compare with the surface of the earth?

3. What do you think the bottom of the ocean is like? Would it be the same at the mouths of great rivers as elsewhere?

4. What do the rivers pour into the oceans besides their waters? What finally becomes of their various kinds of freight?

5. Does the sediment carried by rivers ever get in man's way? How is it removed? Why does each Congress pass a "river and harbor bill"?

6. Is the ocean uniform in depth throughout? How is the depth of the ocean measured? Why do sailors have to do this quite often?

Note.—The sea is about as deep as the mountains are high. Its depth is measured by means of a heavy weight fastened to the end of a very long piano wire in such a way that when it touches the bottom it will come off. The wire is marked so as to show what length has been lowered, and is wound back on to a great reel much more easily without the weight than if it remained attached.

7. How do men find out what is at the bottom of the sea? Suggest a way to explore the sea bottom.

SEA DREDGING

8. Do you think that gravel found there would be worn round, as in surface waters? Why?

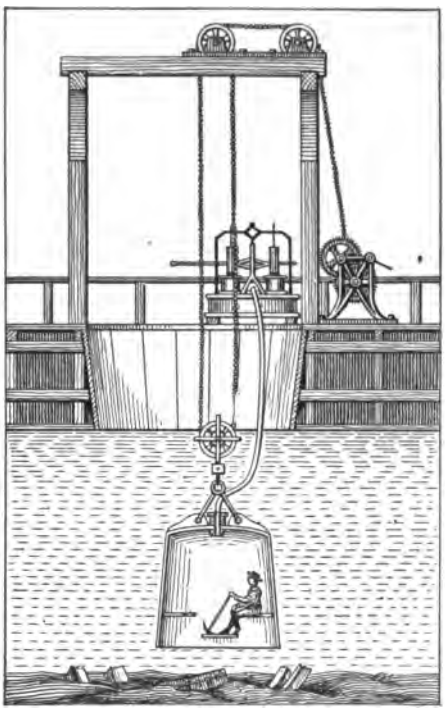
9. Describe a deep-sea dredge and its use.

10. How deep do waves disturb the sea? How deep does sunlight penetrate the ocean waters?

11. Why are so many of the deep-sea fish phosphorescent, or able to emit light, like a match rubbed gently in the dark?

12. Describe specimens of sea plants that you may have

seen. What are the chief differences between them and land plants? Account for these differences.



Diving Bell

13. Study a physical map of the sea bottom, if you can get one. Of what use to sailors are the maps and the charts of the sea bottom?

14. If the sea were to dry up, what would its bed look like?

15. Which ocean is the deepest? Do you know of islands that are mountain tops above the water?

16. Where is the Atlantic cable laid between America and Europe? Can you give a reason for laying it there? Would they want it in deep or in shallow water?

17. What do men get by diving into shallow portions of the ocean?

18. Tell what you can of pearl fishing; of procuring coral, sponges, oysters, etc., from the sea bottom.

19. Describe a diving bell and the manner of using it.

LESSON XXVIII

GRASSES

1. Name and describe as many kinds of grass as you know.

2. Dig up samples of a few kinds entire, wash the roots clean, and mount or otherwise preserve them for study.

3. When cultivated ground is neglected, which comes on it first, weeds or grass? Which in the end more often gets possession? Refer to instances that you have seen.

4. How is it that the slender grass can drive out great stout weeds?

5. How does grass creep? Do all grasses have this habit?

6. Which grasses "stool"? When is this an advantage to man? When is it a disadvantage?

7. Which grasses are annuals? Which are perennials? How can you find out?

8. Examine roots, as well as tops, and see if any stored food is found in them.

9. Which grasses produce the most numerous or the largest seeds, the annuals, or the perennials? Suggest a reason.

Note.—Most of the useful grains, as well as foxtail, chess, timothy, redtop, and other varieties found in the lawn or meadow, are classified with the grass family.

10. Compare them and find similarities in structure.

11. Mention grasses that grow in swampy places; in less moist places; in dry places. Find adaptations to these conditions in the different plants.

12. How do grasses contrive to get enough light? Describe the stems of different grasses. What are the most common forms?

Experiment.—Roll a sheet of paper around a pencil and remove the pencil. Compare its resistance to that of a flat sheet of paper.

13. Account for the rigidity of a hollow tube. Apply the principle to explain the strength of grass stems.

14. Why do the stems of grasses need to be strong?

15. What is the value of the joints in them? Notice their construction.

16. When a stem is bent or trodden down, how does it succeed in gaining an erect position again?

17. Why are windy places favorable to grass crops, especially to grains such as wheat, barley, and corn?

18. How are the seeds of grass distributed? How are their flowers fertilized?

LESSON XXIX

SIDEWALKS AND STREETS

1. What is the condition of the sidewalks in your town?

2. Which are paved? Which are graveled? Which are muddy in bad weather?

3. How do good walks contribute to comfort? to health? to economy?

4. Which sidewalks are graded before being paved? Explain why this is necessary.

5. Tell how paving is done, and what materials are used.

6. Are any of the streets of your town paved? Which? Why? What is the effect of much travel upon streets in muddy weather? in dry weather?

7. How do bad roads lessen the amount of work that men and teams can do in a day?

8. In what ways do bad roads increase the expense of the public?

9. Why should city streets and sidewalks be paved?

10. Tell what you can about the manner of paving streets: the materials used; their cost, durability, etc.

11. Who is your street supervisor? What are his duties?

12. Why should the walks and the streets be kept clean? Who does this work?

13. Describe modern methods of cleaning streets.

14. How do clean streets affect the health of the people?

15. How has yellow fever been almost stamped out of our large southern cities, where it used to be so common?

16. How does cleanliness in both streets and yards lessen the number of house flies and mosquitoes?

17. What part do these insects often perform in the spread of disease?

18. In what ways is dust dangerous? Does sprinkling our streets in dry weather pay?

19. Describe the methods used in caring for our streets —in washing, sweeping, sprinkling, and in removing snow and garbage from them.

20. What benefits come from caring for them properly? Consider health, comfort, convenience, beauty, economy, employment given, etc.

21. How may country roads be improved where paveing would be too expensive?

LESSON XXX

THE RABBIT

To THE TEACHER.—The pupils should make an intelligent study of several animals—the choice depending upon the ones available. If possible, get one of the pupils to bring a rabbit to school, where all may observe its appearance, movements, and habits. If no rabbit can be procured, substitute a cat, dog, dove, or other animal that can be obtained, and modify the lesson accordingly.

1. Name and describe different breeds of rabbits with which you are acquainted.

2. What care should tame rabbits receive?

3. Where are wild rabbits found? What kinds of food do they eat?

4. At what time of day do they feed most freely? What is the best time of day to hunt rabbits?

5. How does the rabbit eat? How does it drink? Why is its lip "split"?

6. Describe the rabbit's movements. How and when does it walk? hop? jump?

7. If possible, notice the footprints of the rabbit, and draw them as he hops or jumps. Which is its favorite way of going?

8. Compare the various features of the rabbit with those of the cat, dog, or other domestic animals, and note the adaptations of parts to the needs of their owner.

9. Describe the rabbit's head. Account for the size, shape, and movements of the ears. Is its hearing acute? Why?

10. Describe the position and size of the eyes and their range of vision. Describe the rabbit's nose and lips and teeth.

11. Upon what does the rabbit chiefly depend for safety from its enemies?

12. What are the natural enemies of the rabbit? To what diseases are rabbits subject?

13. What can you say of their rate of increase? Do they ever become a pest?

14. What harm do they do when they become too numerous? How are their numbers held in check?

15. What other animals have long, chisel-shaped front teeth?

16. For what are these teeth used by their respective owners? Why are such animals called "gnawers"? Name all the animals that gnaw.

17. What rabbits live in burrows? How do they dig burrows? Describe the feet of a rabbit, and show the difference in structure and use between the front and the hind feet and legs.

18. How do rabbits manage to hop so noiselessly? Why is this necessary?

19. How do they travel so well over soft snow? Why?

20. Draw the rabbit in various positions — in motion and at rest.

21. What can you say of the rabbit's disposition?

22. What breed can be raised most profitably?

LESSON XXXI

BACTERIA

Note.—Bacteria are perhaps the smallest, most numerous, and most active organisms that we know. They multiply under favorable conditions at a rate that we can scarcely conceive, and are capable of doing the greatest good or harm, according to the kind of work they do.

Experiment 1.—Fill two test tubes that are perfectly clean with a culture of some kind. Water in which bread, boiled potato, meat, or other organic substances have been soaked will make a culture. Filter, if it is not clear. After filling the test tubes, boil them, to sterilize the culture, and keep them closed with balls of clean cotton. Sow in one of them a little dust taken from anywhere in the shoolroom where sunshine does not reach it. Set them aside a day or two, and compare the one containing the dust with the one in which no dust was placed.

1. Describe and account for the change in the appearance of the liquid.

2. If accustomed to use a compound microscope, you may examine the growth in the test tube with one.

Experiment 2.—Cut a boiled potato in two with a clean knife that has been in boiling water for a few moments, and sprinkle a little dust on the newly exposed surface. Set aside and watch for the growth of bacteria or mold. The potato should be kept warm and damp, and may be covered to keep other dust from settling on it.

3. Whence came the germs that produce the growth?

4. Study samples of mold, decay, blight, etc. How do spores come to attack the specimens?

5. What conditions favor their growth?

6. How does sunshine affect their growth?

7. Compare the action of the spores and the germs to that of seeds in germinating and growing.

8. Whence comes the dust that is everywhere present and settles continuously upon the furniture and contents of rooms at home and at school?

Note.—Careful experiments prove that contagious diseases are caused by bacteria. These grow and multiply in the body of the affected person in great numbers, and their spores or germs are sent out from them in the breath, or through the skin or other organs of excretion.

9. How may disease germs be received by one person from another? Do you know of instances of such happenings?

10. Think of precautions to prevent the spread of such diseases.

11. What common habits are dangerous on this account?

12. Why should our homes and schoolrooms be kept free from dust? In dusting, which is better—to use a feather duster or a damp cloth? Why?

13. Why are rugs better than carpets? Are window curtains, draperies, etc., conducive to the health of the family? Why?

14. What danger is there in using the towel, soap, comb, brush, drinking cup, etc., in a public place?

15. Why are there laws against spitting in public places?

16. Think of other ways in which a diseased person is liable to scatter disease germs where other persons may get them.

17. Study the provisions of the local health laws.

18. Explain how and why rooms, bedding, etc., are disinfected after having been used by patients suffering from contagious diseases.

Note.—When our bodies are in perfect health, there is little material within us on which disease germs can live, and there is little danger from contagious diseases; but when weakened from any cause, or poisoned by liquor, tobacco, or other narcotics, there is much greater danger.

19. The Board of Health in one of our large cities gave the following directions to all the schools there. Infer a reason for each.

Teach the Children

Not to spit; it is rarely necessary. To spit upon a slate, floor, or sidewalk is an abomination.

Not to put the fingers into the mouth.

Not to pick the nose.

Not to wet the fingers with saliva in turning the leaves of books.

Not to put pencils in the mouth or to moisten them with the lips.

Not to put money into the mouth.

Not to put anything into the mouth except food and drink.

Not to "swap" apple cores, candy, chewing gum, half-eaten food, whistles, bean blowers, or anything that is habitually put into the mouth.

To wash the hands and the face often. See that the children are kept clean.

To turn the face aside when coughing or sneezing in the presence of others.

LESSON XXXII

HOME SANITATION

1. In building a home, or in selecting a house to rent, what care should be taken to secure a healthful home? Tell what are desirable and undesirable conditions about the following points, and why: location, frontage, drainage, sunshine, windows, ventilation, cellar, water supply, prevailing winds, condition of the neighborhood, etc.

2. How should the home be furnished, with a view to making it and keeping it sanitary with the least difficulty and labor? Should floors be bare, painted, covered with rugs or carpets? Consider the needs in each room.

3. Should the walls be bare or papered? Should they be hung with many pictures and decorations or with few?

If pictures are used, should they be tilted forward or hung flat against the walls? Why?

4. How should a bathroom be fitted up? a kitchen? a dining room? a living room?

5. How should a home be heated? Consider the old-fashioned fireplace, the base burner, and other coal heaters, the gas stove, and the coal-oil stove. Study different forms of modern furnaces also in their relations to the health of the family.

6. Describe good and poor ways of ventilating a home. When and why should windows and transoms be open? Is cold air always pure?

7. Why should clothing and bedding, as well as bedrooms, be aired and sunned frequently? Recall the work done on ventilation and respiration.

8. What kind of light is best for the eyes? Why should sunlight reach every room? Compare the light from a coal-oil lamp, gas jet, and electric lamp in their effects upon the eyes. Consider the value of lamp shades and eye shades.

9. Should we try to read by moonlight or by any dim light? Why? What is the effect upon the eyes of light that is too strong?

10. Most cities have good water systems, but if making a home in the country, what precautions are necessary in getting a water supply? If water comes from a well, what dangers may there be? Consider cesspools, barnyards, and other sources of contamination. If water comes from canals or brooks, why may it be impure?

11. Visit and study the city water system and the care given by the proper officers to keep the water pure.

12. How should the waste waters and the sewage of a home be disposed of in a city? in the country? Study the sewer system of the city. How are cesspools, septic tanks, etc., used in the country to dispose of the sewage?

13. What finally becomes of the sewage of large cities?

14. Where should stables and barnyards be located with reference to dwellings? What care should they get?

15. What care should be taken of the dooryard and the surroundings of dwellings to insure good health? Where have you seen unsanitary dooryards, streets, etc.? Why are they dangerous? How could they be improved?

16. What danger comes from poor or defective plumbing? Why should all the plumbing be kept in good repair?

17. How do good window and door screens affect the health of the family?

18. What are the chief sources of injurious gases, dust, and germs that enter the home? How may they best be excluded?

19. Why are cellars often unsanitary?

20. What trades and occupations are unhealthful? Explain the reasons why, and suggest remedies for improving them.

21. What habits often seen in homes are destructive to health? Consider: eating in haste; overeating; the use of tea, coffee, tobacco, and liquor; narcotics, insufficient sleep; irregular eating, sleeping, etc.; overwork; neglect to bathe; lack of exercise, open air, and sunshine; worry, etc.

22. What precautions should be taken in case of a contagious disease to protect the rest of the family and the neighbors?

23. Study quarantine laws and regulations and the reasons for them.

24. What is good health worth to us?

LESSON XXXIII

BREAD MAKING

1. Why is bread called the "staff of life"? To what extent is it used?

2. Describe the different kinds of bread, and tell from what each kind is made.

3. What are the general properties of good bread? Consider the crust, the interior of the loaf, the crumbs, the odor, the taste, etc.

4. Visit a bakery and study the various processes used in making bread.

5. Describe orally, or in writing, what you saw and learned at the bakery.

6. If possible, make some bread at home, and then tell the class how it is done.

Experiment 1.—Place a small quantity of yeast in a little flour mixed with tepid water so as to form a paste. Keep the mixture moderately warm, and describe what takes place.

7. How is the bread made "light" or spongy?

Experiment 2.—Put some yeast into a bottle of water containing about ten per cent of sirup and watch the results. Examine with a compound microscope the yeast plants that form in this liquid.

8. Would yeast plants form as well in water that is not sweetened?

Experiment 3.—Chew some bread for a long time, and note if it becomes sweeter. Recall the change in the taste of seeds as they begin to germinate. (See Lesson 39, Grade 2.)

Note.—The yeast plants live upon the sugary substances that come from the starch in the flour, and, as fermentation proceeds, they give off as waste products alcohol and bubbles of carbon dioxide gas.

9. When the yeast is mixed throughout the dough, what effect will the generation of this gas have upon the dough?

10. How is the yeast mixed thoroughly in the dough?

11. How will the heat of the oven affect the dough?

12. How will the heat affect the alcohol and the carbonic acid gas in the dough when put into the oven?

13. Why is a hot oven needed to bake the loaf? What will be the result if the oven is too hot? too cold?

Note.—If you have no thermometer to test the heat of the oven, a spoonful of flour should turn slightly brown in sixty seconds when placed in an oven of the proper temperature to bake bread.

14. Why is the sponge and the dough each allowed to rise before being baked? Why are they kept warm?

15. What will be the result if the dough is allowed to rise too long? not long enough?

16. If Experiment 2 be continued a long time, what takes place in the liquid?

Note.—In this kind of fermentation, alcohol is at first produced, and afterwards, vinegar.

17. Tell what you know of the manufacture of alcohol and vinegar from grain.

18. Account for "sour" bread.

LESSON XXXIV

THE CITY FIRE DEPARTMENT

1. Give an account of any burning building that you may have seen.

2. Tell what you can of any serious fire that you have heard about. Consider the cause; the damage done; the work of the firemen; danger to other buildings, etc.

3. Name frequent causes of fires. In what ways are people often careless about causing a fire?

4. What precautions may we take to prevent fires in our homes?

5. How may incipient fires be put out?

6. On what buildings does the law require fire escapes? Why?

7. What is the value of fire drills at school?

8. What should we do in case of a fire at home? at school? at a theater? at a factory?

9. What should we not do that is often done on such occasions? What laws of physics may be of use in case of a fire?

10. What do you know about fire extinguishers?

11. Visit a fire department station and learn all that you can about their vigilance, implements, and work. Consider the engine; the horses and their training; the hose cart and its use; the hook and ladder apparatus and its value.

12. Describe the work that the different men do in case of fire.

13. Why is the greatest possible haste necessary in case of fire? In what ways is haste secured?

14. Describe various ways in which firemen rescue people from burning buildings.

15. How many fire stations are there in your town? How are they distributed? Why?

16. Compare the modern fire engine with the old-time hand pump.

17. Describe a "bucket brigade" and its work in extinguishing a fire.

18. How are firemen dressed? Why? Describe a fire helmet.

19. Do ships ever burn?

20. Tell what you can of a fire boat and the work it is often called upon to do in harbors.

21. Why do most business men carry fire insurance on their property? Tell what you know of fire insurance.

22. What do you know of prairie fires and the damage that they often do?

23. How are forest fires often caused? What great damage do they frequently do?

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